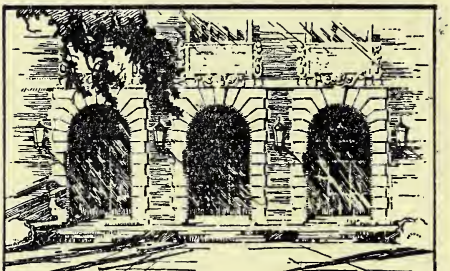


LIBRARY
OF THE
UNIVERSITY
OF ILLINOIS
621.351
C65m

ENGINEERING

DATE DUE

13 AU
30 O
15 NO
21 JAN
7 FEB
3 AP
15 AP
21 Ja
23
9
4 M
17
8
4 Ma
27 M
OCT 27 19
JAN 25 1

The person charging this material is responsible for its return to the library from which it was withdrawn on or before the **Latest Date** stamped below.

Theft, mutilation, and underlining of books are reasons for disciplinary action and may result in dismissal from the University.

UNIVERSITY OF ILLINOIS LIBRARY AT URBANA-CHAMPAIGN

ENGINEERING

OCT 17 1981
OCT 27 Rec'd
JUL 15 1982
AUG 31 REC'D
OCT 07 1985
SEP 20 REC'D
MAR 03 1986
FEB 2
JAN 02 1991
FEB 05 REC'D
NOV 30 REC'D
NOV 20
DEC 07 2002

L161—O-1096

THE MODERN ELECTROPLATER

A complete book considering fully the elementary principles of Electro Deposition of Metals, their practical application and industrial use.

Includes

A discussion of the essential fundamentals of Chemistry, Magnetism and Electricity, written with special reference to the needs of the practical man; considers the equipment and supplies required for a successful plating plant and describes all the latest processes of cleaning, plating and finishing metals on a commercial scale.

BY

KENNETH M. COGGESHALL

Electrical Engineer

Including Valuable Tables and Tested Formulas

NEW YORK
THE NORMAN W. HENLEY PUBLISHING CO.
2 West 45th Street
1920

Copyrighted, 1920
By
THE NORMAN W. HENLEY PUBLISHING COMPANY

Printed in U. S. A.

PUBLISHERS PRINTING COMPANY, NEW YORK

621.351
C65

ENGINEERING
LIBRARY

PREFACE

THE aim of this book is not scientific, but practical. An attempt has been made to describe the equipment and to explain the practical methods of modern electroplating in the simplest possible terms. No material has been put into the book which does not bear directly upon the subject of electro-deposition. For example, only the essential fundamentals of magnetism, electricity, and chemistry have been considered.

Chapter VIII, which deals with electrolytic solutions and plating methods, is presented with the cooperation of Mr. Harry Duebelbeis, president of the American Electroplaters' Society, St. Louis Branch.

The author takes this opportunity of expressing his indebtedness to his father and to Mr. Mark Moody for many valuable suggestions and friendly criticisms.

The writer is also under obligations to several manufacturers and suppliers for cuts and illustrations of plating and polishing room equipment. Acknowledgment is given with the title for the illustrations furnished by the Mott Sand Blast Co., the L. S. Starrett Co., Crown Rheostat & Supply Co., General Platers' Supply Co., A. P. Munning & Co., The Baird Machine Co., Sangamo Electric Co., and Bennett O'Connell Co.

August, 1920. KENNETH M. COGGESHALL.

500516

Digitized by the Internet Archive
in 2016 with funding from
University of Illinois Urbana-Champaign

https://archive.org/details/modernelectropla00cogg_0

CONTENTS

CHAPTER I

THE ADVANCE OF THE ELECTROPLATING INDUSTRY

Electroplating: a Definition—Development of the Industry—Metal Deposition for Protection—Electrotyping—Deposition of Precious Metals—Research Work—An Essential Industry—Future Development . . . . Page 11

CHAPTER II

ELEMENTARY CHEMISTRY AND ELECTRICITY

Chemical Affinity—Elements—Compounds—Chemical Symbols—Tabulation of Elements—Atomic Theory—Atoms — Molecules — Law of Multiple Proportions — Acids — Bases—Salts—Chemical Equations—Common and Technical Names — Solids and Solutions — Electro-Chemical Action — Electrolysis — Electro-Deposition of Metals — Faraday's Laws — Electrical Conductors — The Electric Circuit—The Ampere—The Volt—Potential Difference —The Ohm—Resistance Factors—Series Circuits—Parallel Circuits—The Coulomb—The Joule—The Watt—The Watt-Hour—The Horse Power . . . . . . Page 16

CHAPTER III

THE LOCATION AND CONSTRUCTION OF THE PLATING ROOM

Three Factors—The Individual Shop—The Factory Department — General Requirements — Floor Plan — Generator Location—Floor Drainage—Wooden Floor Construction —Acid Proof Walls—Ventilation—Illumination—Heating . . . . Page 40

CHAPTER IV

ELECTRICAL EQUIPMENT FOR THE PLATING ROOM

Current Supply—The Generator—The Electro-Magnet—The Field Magnet — Four Types — Series Generator — Shunt Generator—Compound Generator—The Separately Excited Shunt Generator—The Armature—The Commutator—The Armature Winding—The Brushes—The Bearings — Capacity — Location — Driving Unit — Motor Capacity—Motor Speed—Generator Voltage Regulation—Generator Field Rheostat — The Ammeter — The Voltmeter—The Amperehour Meter—Tank—Rheostat—Two-Wire System—Three-Wire System . . . . Page 52

CHAPTER V

ELECTROPLATING TANK EQUIPMENT

Tank Capacity—Three-Types of Plating Tanks—Still Tanks —Earthenware Tanks—Steel Tanks—Wooden Tanks—Tank Construction—Advantage of Warm Plating Baths

—Steam Coil Heater—Insulating Joint—Regulating Valve—Solution Agitation—Agitation with Air—Tank Rods—Plumbing—Rotating Plating Barrels—Automatic Plating Machinery—Automatic Moving Tank—Principal Advantages—General Design—Other Types—Tanks for Preparatory Processes—Pickling Tanks—Bright Dipping Tanks—Special Ventilating Hoods—Lye and Potash Tanks—Hot Water Tanks—Scouring Tanks . Page 82

CHAPTER VI

MISCELLANEOUS PLATING ROOM EQUIPMENT

The Steam Generator—The Drying Oven—Hot Sawdust Box—Air Compressor—Time Dial—Plating Anodes—Flat Anodes—Corrugated Anodes—Elliptic Anodes—Curved Anodes—Slinging Wire—Plating Baskets—Plating Hooks—Plating Racks—Special Racks—Dipping Baskets—The Respirator—The Hydrometer—The Thermometer—Litmus Paper—Acid Pump—Carboy Inclinator—Speed Indicator—Clothing . . . . Page 116

CHAPTER VII

THE PREPARATION OF WORK FOR ELECTRO-PLATING

Cleansing—Removal of Burrs—Oblique Tumbler—Horizontal Tumbler—Charging the Tumbler—Sand Blasting—Two-Hose Sand Blast—Single-Hose Sand Blast—Sand Blast Room—Automatic Sand Blast—Sand Blast Rolling Barrel—Rotating Table Sand Blast—Compressed Air Supply—Sand Blast Sand—Cleansing by Pickling—Rinsing—Electrolytic Cleaning—Copper Striking—Polishing—Hot Lye Dipping—Scratch Brushing—Scouring—Removing Oxides—Stripping—Non-Metallic Work—Bright Dipping . . . . Page 139

CHAPTER VIII

PLATING SOLUTIONS AND THE ELECTRO-DEPOSITION OF METALS

Brass — Brass Plating Solution — Brass Anodes — Voltage Regulation for Brass Plating—Brass Coloring—Bronze—Bronze Plating Solution—Brass Anodes—Voltage Regulation for Bronze Plating — Copper — Copper Plating Solutions for Still Tank — Catalytic Agents — Copper Anodes—Voltage Regulation for Copper Plating—Copper Deposition—Copper Striking—Copper Coloring—Gold—Gold Plating Solution—Gold Anodes—Voltage Regulations for Gold Plating—Gold Deposition—Stop-Off Varnish—Iron—Iron Plating Solution—Iron Anodes—Voltage Regulation for Iron Plating—Lead—Lead Plating Solution—Lead Anodes—Voltage Regulation for Lead Plating—Nickel—Solutions for Still Tank Nickel Plating—Solution for Barrel Nickel Plating—Black Nickeling — Nickel Anodes — Voltage Regulation for Nickel Plating — Preparation of Work for Nickel Plating — Nickel Deposition—Silver—Silver Plating Solution—Silver Anodes—Voltage Regulation for Silver Plating —Silver Deposition—Silver Coloring—Tin—Tin Plating Solution — Tin Anodes — Voltage Regulation for Tin Plating — Tin Deposition — Zinc — Electro-Galvanizing — Solutions for Still Tank Zinc Plating—Solution for Barrel Zinc Plating—Zinc Anodes—Voltage Regulation for Zinc Plating — Zinc Deposition — Mechanical Machinery for Electro-Galvanizing . . . . Page 162

CHAPTER IX

POLISHING, BUFFING, AND LACQUERING

The Polishing Room—The Motor Driven Lathe—The Belt-Driven Lathe — Overhanging Lathes — Belt Strapping

—Grinding Lathes—Surface Grinders—Portable Grinders—Dust Collector Hoods—Polishing—Polishing Wheels — Gluing the Wheels — Cleaning the Wheels — Emery Applications—The Glue Heater—Emery Trough—Buffing—Buffing Wheels—Buffing Compositions—Speed of Buffs—Scratch Brushes — Burnishing Barrel — Lacquering—The Lacquer Room—Lacquer Application—Colored Lacquer . . . . Page 194

CHAPTER X

USEFUL REFERENCE DATA

(A) The Maintenance and Repair of a Plating Generator—Building Up—Low Voltage—Reversal of Current Direction—Commutator Sparking—Armature Troubles—Testing for Open Circuit—Testing for Short Circuit—Testing for Grounds—Field Troubles—Bearing Troubles—Unusual Noises—(B) The Transmission of Power—Shaft Drive—Pulleys—Belts—Rules for Speed—(C) Resuscitation from Electric Shock or Asphyxiation—Quick Action —Preliminary Treatment—Loosen Clothing—Resuscitation—Warmth—Patience—(D) Antidote for Poisons—(E) Conductivity of Common Metals—(F) Comparison of Thermometers—(G) Miscellaneous Data—(H) Fluxes for Soldering or Welding—Amperes Required to Plate One Square Foot of Surface—Weight of Metal Deposited per Amperehour—Round Copper Conductors for Plating Currents—Decimal Equivalents . . . . Page 231

The Modern Electroplater

CHAPTER I

THE ADVANCE OF THE ELECTROPLATING INDUSTRY

Electroplating: a Definition—Development of the Industry—Metal Deposition for Protection—Electrotyping—Deposition of Precious Metals—Research Work—An Essential Industry—Future Development.

ELECTROPLATING

Electroplating consists in the deposition of a layer of metal upon an object through the action of electrolysis.

DEVELOPMENT OF THE INDUSTRY

Although the discovery of electro-deposition was made in 1805, it was not until 1837 that Spencer and Jacobi made use of the phenomenon for practical purposes. Scientific investigation, continued in the laboratories, developed and broadened the scope of the subject. Gradually the possibilities of the art of electroplating became apparent to manufacturers who adapted the process to electrotyping, as well as to the coating of small articles. Only recently has the chemist considered electroplating as an important industry well worthy of his serious study. Careful laboratory investigations, concentrated study of chemical and electrical phenomena, combined with practical experience, have evolved processes and formulæ designed to produce definite results and perfect deposition at a minimum cost. Moreover, manufacturers of electroplating machinery, stimulated perhaps by competition, have year by year improved their apparatus in an effort to gain the highest degree of efficiency. The modern electroplater is quick to grasp and employ to his advantage every new process as well as every improvement in labor saving machinery.

METAL DEPOSITION FOR PROTECTION

It is well known that iron and steel products corrode or rust quickly if exposed directly to the atmosphere. Yet because the metals are available in large quantities, are comparatively inexpensive, and since they are strong and durable, commercial practice demands their use. Thus, some protective coating must be used, whether it be paint, varnish, or a layer of non-corrosive metal. In some instances paint or varnish may be used, but greater satisfaction results if a thin deposit of zinc, nickel, tin, or copper is applied. These metals not only afford the necessary protection but greatly improve the appearance of the treated product. Zinc, unlike tin or nickel, is electro-positive to iron and is, therefore, an excellent protective agent. Moreover, its cost is less than the other metals mentioned. Nickel, however, because of the high polish it takes on the buffing wheel, is usually employed as a coating for hardware and other parts requiring a beautiful, finished surface. Tin is not used to as great an extent as the others, but copper is often employed. Undoubtedly the deposition of protective metals is at present the most important phase of the electroplating industry. Indeed, electro-galvanizing or zinc plating is of such importance that entire plants are equipped solely for that work.

ELECTROTYPING

Type and other objects may be reproduced by the electro deposition of copper upon a mould of the original. Thus, any number of exact metallic reproductions may be made from the original type or cut. Perhaps no other art has assisted to so great a degree the progress of the printing industry as has electroplating.

DEPOSITION OF PRECIOUS METALS

Although the greatest volume of work passing through most plating rooms at the present time calls for the deposition of protective metals, gold and silver plating, particularly the latter, have a wide application. Usually the deposition of these metals is done for ornamental purposes. Jewelry, cutlery, table ware, and similar articles made from baser metals, are coated with gold and silver to improve their appearance as well as to increase their value.

RESEARCH WORK

The applications of the art of electroplating just mentioned are only the most important. The field is continually growing broader. In a great measure the future development of this industry depends upon the interchanging of experiences and opinions of electroplaters through the channels of the various trade papers and societies. The United States Bureau of Standards is carrying on research work with the expectation of solving many of the existing plating problems as well as presenting new processes, solutions, and other interesting data.

AN ESSENTIAL INDUSTRY

The World War, to a certain degree, assisted in placing electroplating among the essential industries. Manufacturers accustomed to the use of brass or copper suddenly found those metals listed as necessary for the production of munitions. Thus other metals were employed and electroplated to secure the desired finish. Quantities of rejected underweight steel explosive shells were salvaged by the electro-deposition of lead upon their interior walls. Countless steel parts were zinc plated as a protection against exposure to the atmosphere. The writer, for instance, was interested in the production of thousands of "depth bombs," practically every part of which passed through the plating room. Under the pressure of war work many plating establishments, of necessity, applied the rules of efficiency, purchased new machinery, and, using the same floor space, increased production to a previously unthought-of extent. These lessons cannot soon be forgotten.

FUTURE DEVELOPMENT

Automatic machinery is appearing to lessen the labor of plating, as well as to reduce its cost. The modern plating room is equipped with plating barrels, automatic conveyors for still tanks, steel ball burnishers, and similar apparatus. The plating room of the future will be equipped entirely with such labor-saving machinery; operations will be standardized; work will move in a definite path through the room; the quality of the deposit will be uniform, and quantity production will be demanded.

CHAPTER II

ELEMENTARY CHEMISTRY AND ELECTRICITY

Chemical Affinity—Elements—Compounds—Chemical Symbols—Tabulation of Elements—Atomic Theory—Atoms—Molecules—Law of Multiple Proportions—Acids—Bases—Salts—Chemical Equations—Common and Technical Names—Solids and Solutions—Electro-Chemical Action—Electrolysis—Electro-Deposition of Metals—Faraday's Laws—Electrical Conductors—The Electric Circuit—The Ampere—The Volt—Potential Difference—The Ohm—Resistance Factors—Series Circuits—Parallel Circuits—The Coulomb—The Joule—The Watt—The Watt-Hour—The Horse Power.

It is not necessary that an electroplater be a careful student of either electricity or chemistry. A technical discussion of the laws relating to electro-chemistry would, undoubtedly, have but little interest for even an expert plater. His attention is usually directed first and chiefly to the *how* rather than the *why* of electro-deposition. Progress is stimulated, however, by taking advantage of the experience of co-workers in the art of plating, and proceeding with the work from the point to which others have advanced it. Much of such useful information is found in current magazines of the trade expressed in the form of chemical equations or written in terms of electrical units. Thus, a brief review of the fundamental facts and principles of these subjects should prove helpful to the electroplater.

CHEMICAL AFFINITY

It was discovered, some few years ago, that most substances can, by chemical action, be converted into more simple substances. At present about eighty substances are known which cannot be further decomposed; these the scientists term elements. As yet it is not fully understood what power holds the elements together in the many combinations. This phenomenon, causing various substances to form in combinations of two to six or more elements, is termed chemical affinity. Fortunately, but few elements are of concern to the electroplater.

ELEMENTS

Elements are those substances incapable of separation into other kinds of matter. Metals, such as iron, lead, zinc, gold and silver, are elements, as are also gases, like hydrogen, nitrogen, oxygen and chlorine. Not all elements are conductors of electricity; some are not even good conductors of heat.

COMPOUNDS

Compounds, as the name implies, are composed of several substances. It is therefore true that a compound may be broken up into the elements of which it is composed. Water, H_2O, the most bountiful of all compounds, is composed of two familiar elements, hydrogen and oxygen. As a further example, silver nitrate, $AgNO_3$, can be separated into the elements silver, nitrogen, and oxygen, of which it is compounded.

CHEMICAL SYMBOLS

It would not be an easy matter to express a chemical substance or reaction by writing out in full the name of each element involved. To save time, therefore, as well as to express a letter picture of the combination of elements, a kind of shorthand has been evolved to represent the names of substances.

In a number of instances the first letter of the Latin name is the symbol. Thus, the Latin name for potassium is Kalium, and K is the symbol for that element. Other symbols take the first letter and some other letter in the word. For instance, tin is Stannum in Latin, and Sn is the chemical symbol. As will be noticed, however, from the following list of elements, most of the symbols have their origin in the English name; as H for hydrogen and Cl for chlorine.

TABULATION OF ELEMENTS

ELEMENT	SYMBOL	ATOMIC WEIGHT
Aluminum	Al	27.1
Antimony	Sb	120.2
Argon	A	39.9
Arsenic	As	75.
Barium	Ba	137.4
Bismuth	Bi	208.
Boron	B	11.
Bromine	Br	79.96
Cadmium	Cd	112.4
Cæsium	Cs	132.9
Calcium	Ca	40.1
Carbon	C	12.
Cerium	Ce	140.25

ELEMENT	SYMBOL	ATOMIC WEIGHT
Chlorine	Cl	35.45
Chromium	Cr	52.1
Cobalt	Co	59.
Columbium	Cb	94.
Copper	Cu	63.6
Erbium	E	166.
Europium	Eu	152.
Fluorine	F	19.
Gadolinium	Gd	156.
Gallium	Ga	70.
Germanium	Ge	72.5
Glucinum	Gl	9.1
Gold	Au	197.2
Helium	He	4.
Hydrogen	H	1.008
Indium	In	115.
Iodine	I	126.97
Iridium	Ir	193.
Iron	Fe	55.9
Krypton	Kr	81.8
Lanthanum	La	138.9
Lead	Pb	206.9
Lithium	Li	7.03
Magnesium	Mg	24.36
Manganese	Mn	55.
Mercury	Hg	200.
Molybdenum	Mo	96.
Neodymium	Nd	143.6
Neon	Ne	20.
Nickel	Ni	58.7
Nitrogen	N	14.01
Osmium	Os	191.
Oxygen	O	16.
Palladium	Pd	106.5
Phosphorous	P	31.
Platinum	Pt	194.8
Potassium	K	39.15
Praseodynium	Pr.	140.5
Radium	Ra	225.
Rhodium	Rh	103.
Rubidium	Rb	85.5
Ruthenium	Ru	101.7
Samarium	Sm	150.3
Scandium	Sc	44.1
Selenium	Se	79.2
Silicon	Si	28.4
Silver	Ag	107.93

ELEMENT	SYMBOL	ATOMIC WEIGHT
Sodium	Na	23.05
Strontium	Sr	87.6
Sulphur	S	32.06
Tantalum	Ta	181.
Tellurium	Te	127.6
Terbium	Tb	159.2
Thallium	Tl	204.1
Thorium	Th	232.5
Thulium	Tu	171.
Tin	Sn	119.
Titanium	Ti	48.1
Tungsten	W	184.
Uranium	U	238.5
Vanadium	V	51.2
Xenon	X	128.
Ytterbium	Yb	173.
Yttrium	Y	89.
Zinc	Zn	65.4
Zirconium	Zr	90.6

ATOMIC THEORY

In order that the combinations of elements as expressed in chemical formulæ may be comprehended, the reader must understand something of the atomic theory. It is known that elements combine in definite proportions. Moreover, when elements combine with others in different ways, the relative quantities that make up the combination, in the several instances, follow out definite laws.

ATOMS

Every simple substance or element is supposed to be made up of atoms, all of which are alike and of the same weight. Chemical combination of different substances takes place between these particles or atoms. The atoms of one element have a different weight from those of other elements. It is not necessary to know the absolute weight of the atoms, but the relative weight is most important. The atomic weight of hydrogen is taken as the unit for the system, and for all practical purposes may be considered as unity. By reference to the tabulation it is seen that the atomic weight of chlorine is 35.45. Thus, the familiar hydrochloric acid, HCl, is a compound composed of 35.45 parts by weight of chlorine to 1 part of hydrogen. Common table salt, $NaCl$, is a combination of 23.05 parts by weight of sodium to 35.45 parts of chlorine. In practice the symbols shown in the table are used to express the relative weights. Hence, Al stands for 27.1 parts by weight of aluminum, C for 12 parts by weight of carbon, Sn for the atomic weight of tin, and so on.

MOLECULES

We have now seen that the atom is the smallest particle of an element considered in chemical action. Atoms of several elements, however, may combine to form particles of a larger degree, called molecules. Thus, HCl denotes a molecule of hydrochloric acid, which is composed of an atom of hydrogen and one of chlorine.

When two or more atoms of one element combine with those of other elements, the total number of each above one entering into the combination is indicated by a numeral placed at the lower right hand corner of the letter symbol. Take, for example, the formula for water, H_2O. The numeral 2 appearing after the H denotes that two hydrogen atoms have combined with one of oxygen. Sulphuric acid, H_2SO_4, is so written that the combination is apparent: two hydrogen atoms, one sulphur, and four oxygen atoms. Often the molecular composition is more complex, as is indicated in the formula for ferric sulphate, $Fe_2(SO_4)_3$. As is at once seen, the molecule is composed of: iron, two atoms; sulphur, three atoms, and oxygen, twelve atoms, or a total of seventeen atoms. Some molecules are combinations of a large number of atoms. Note, for example, the formula for the familiar substance sugar: $C_{12}H_{22}O_{11}$.

The number of molecules is expressed by a large numeral preceding the symbol. Hence, if 6 molecules of sulphuric acid are to be used, it is apparent that they would be grouped together and written $6H_2SO_4$.

LAW OF MULTIPLE PROPORTIONS

From the preceding brief discussion of atoms and molecules it is seen that the atoms always combine in definite proportions. But a glance at the formulæ given as examples undoubtedly shows that there must be some law causing the elements to combine in more than one proportion. The law of multiple proportions, first conceived by Dalton, states that the combining weights of elements are always multiples of each other. This law may be more clearly illustrated by the usual example of two elements, A and B. If A combines with a certain weight of B in more than one proportion, then the different combining weights of A with B always show some definite ratio or multiples of each other, such as 1 : 2, 2 : 3. There are many elements that combine in several different ways, but the following tabulation of the multiple proportions of two abundant substances, lead and oxygen, gives a fair example.

Name	Formula	Parts by Weight		Ratio of	
		Pb	O	Pb to O	
Lead Suboxide	Pb_2O	414	16	207	8
Lead Oxide	PbO	207	16	207	16
Lead Sesquioxide ...	Pb_2O_3	414	48	207	24
Lead Peroxide	PbO_2	207	32	207	32

ACIDS

Before going further, a distinction should be made between acids, bases, and salts that are formed by combination of several elements. By studying the symbols of various acids and their reactions with other substances, it will be noticed that an acid always contains hydrogen which it will exchange for a metal, when a metal or its compound is added. Hydrochloric acid, HCl, is an example.

BASES

On the other hand, substances containing a metal in combination with oxygen and hydrogen, which will exchange the metal for hydrogen when an acid is added, are termed bases. Sodium hydroxide, $NaOH$, is a base.

SALTS

When an acid acts upon a base, water and another substance called a salt are formed. Zinc sulphate, $ZnSO_4$, is known as a salt.

CHEMICAL EQUATIONS

To express chemical action, equations are used, similar to those employed in algebra. The action of any substance upon another is indicated by coupling them with a plus sign. The factors in the transformation precede an equality sign and the result of the reaction follows. The sum of the atomic weight, in other words, on one side of the equation must equal the sum of those written on the opposite side. Nothing is lost during a chemical transformation; new substances may be formed, but the same weight of matter is present after the action as before.

It may be interesting to note a few simple changes as represented by an equation. Zinc, when acted upon by sulphuric acid, produces a salt, zinc sulphate, and a gas hydrogen. The story of the chemical transformation may be written in the form of an equation.

$$Zn+H_2SO_4=ZnSO_4+2H$$

The base, ammonium hydroxide, when treated with hydrochloric acid, reacts to give water and ammonium chloride, or what is commercially known as sal ammoniac:

$$NH_4(OH)+HCl=H_2O+NH_4Cl$$

A few other simple chemical reactions, expressed in the form of equations, are given to illustrate further similar transformations:

$$Zn+2HCl=ZnCl_2+2H$$
$$ZnCl_2+2KCN=2KCl+Zn(CN)_2$$
$$Cu+H_2SO_4=CuO+SO_2+H_2O$$
$$CuO+H_2SO_4=CuSO_4+H_2O$$
$$NiCl_2+6NH_3=Ni(NH_3)_6Cl_2$$
$$Ag_2O+2HNO_3=2AgNO_3+H_2O$$
$$NH_3+HCl=NH_4Cl$$
$$NaNO_3+H_2SO_4=NaHSO_4+HNO_3$$
$$PbO_2+4HCl=PbCl_2+2H_2O+2Cl$$

COMMON AND TECHNICAL NAMES

One confusing factor in the study of chemistry is the designation of a given substance by two or more names. For illustration, the familiar blue vitriol or blue stone is technically termed copper sulphate. In like manner, muriatic and hydrochloric acid are identical, although one unfamiliar with the terms might assume them to be two distinct substances. For convenience, a reference tabulation is given, containing the common and technical names of substances often used in the plating room:

Common Name	Technical Name
Baking Soda	Sodium Bicarbonate
Blue Stone	Copper Sulphate
Blue Vitriol	Copper Sulphate
Common Salt	Sodium Chloride
Copperas	Ferrous Sulphate
Corrosive Sublimate	Mercuric Chloride
Glaubers Salts	Sodium Sulphate
Iron Chloride	Ferric Chloride
Iron Oxide	Ferric Oxide
Muriatic Acid	Hydrochloric Acid
Oil of Vitriol	Sulphuric Acid
Prussic Acid	Hydrocyanic Acid
Sal Ammoniac	Ammonium Chloride
Sal Soda	Sodium Carbonate
Saltpetre	Potassium Nitrate
Sugar of Lead	Lead Acetate
Tartar Salts	Potassium Carbonate
Tin Chloride	Stannous Chloride
White Lead	Lead Carbonate
White Vitriol	Zinc Sulphate

SOLIDS AND SOLUTIONS

Chemical action does not readily take place between solid substances, and it is, therefore, often necessary to dissolve them in water. No matter how finely the substances may be divided by pulverizing, the particles are not in as intimate contact with each other as when they are in the liquid state. For this reason, aside from the question of cost and convenience, solutions only are employed in electroplating.

ELECTRO-CHEMICAL ACTION

It was discovered many years ago that chemical and electrical phenomena are often coexistent, or at least closely related. Chemical action between certain metals, or carbon and a metal, when impressed in an acid, for instance, produces an electro-motive force between the two. This is the action of the ordinary primary battery. Water, when an electric current is passed through it, breaks up into its chemical components—hydrogen and oxygen. These are two simple examples of decomposition by electro-chemical action.

ELECTROLYSIS

Electrolysis is the term applied to the decomposition of substances by an electric current. To explain this decomposition, the molecule must be considered as disintegrating into smaller particles, each of which may consist of one or more atoms. These particles, called ions, may be assumed to have positive or negative electrical charges. These differently charged ions move in opposite directions. The ions moving toward the negative electrode or cathode are termed cations;

those moving toward the positive electrode or anode are called anions. The cations of bases and salts are, in general, the metals, while hydrogen is the cation of acids.

ELECTRO-DEPOSITION OF METALS

We now come to the application of the foregoing theory. Suppose an electrolyte is formed by dissolving copper sulphate in water. Into this solution is suspended, as shown in Fig. 1, a copper plate anode and any article of another metal—brass, for example. To the copper plate is connected the positive terminal of a direct current generator or of a battery; to the brass article, the negative terminal. The former plate is the anode, the latter the cathode. In a few moments a light coating of copper is deposited on the

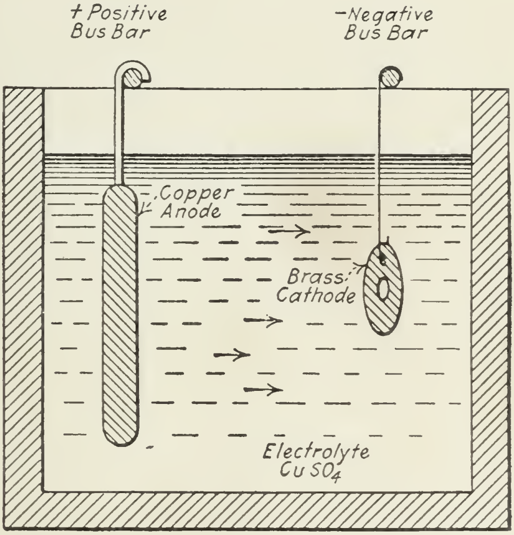


Fig. 1.—Simple Apparatus for Electroplating

brass article, the deposit increasing in thickness as long as the current flow continues and the anode remains. The explanation of this phenomenon is clear from the discussion in the preceding paragraph. The copper, Cu, in the copper sulphate solution is the cation and moves toward the cathode, depositing the copper as it gives up its charge. The SO_4 is the anion and moves to the anode to which it is attracted, where it chemically combines with the copper plate to form copper sulphate, $CuSO_4$. Thus, while the electrolyte is continually replaced, the anode disintegrates as it gives up the copper to the solution.

FARADAY'S LAWS

Two fundamental laws, set forth by Faraday, are of interest to the electroplater, and must be mentioned before passing on to another subject.

The first law states that the weight of any substance discharged at the electrodes in a given time is directly proportional to the quantity of electricity passing through the electrolyte. Thus, in the illustration just given of copper plating, if a certain amount of metal is deposited with one ampere flowing through the electrolyte, twice the deposit might be expected in the same time interval if the current were two amperes.

The second law may be summarized as stating that the amounts of the different substances deposited by a given quantity of electricity bear the same relation to each other as their respective chemical equivalents. The equivalent of any element in chemistry is the amount by weight which may replace or combine with one part by weight of hydrogen. Using again the simple illustration of water, H_2O might be expressed hydrogen 2, oxygen 16. Thus the ratio is eight to one and eight is the chemical equivalent of oxygen. The equivalents of other elements are determined in like manner. The atomic weight, when divided by the equivalent weight, gives a number termed the valency of that element.

ELECTRICAL CONDUCTORS

The effect of the passage of electricity through an electrolyte is to decompose it. Quite different is the result of current flow through a metal conductor. Aside from an increase in temperature, there is no chemical or physical change in the metal.

THE ELECTRIC CIRCUIT

Before there can be a flow of electricity a complete circuit must be established. Such a circuit is indicated in Fig. 2, where it is compared with a simple

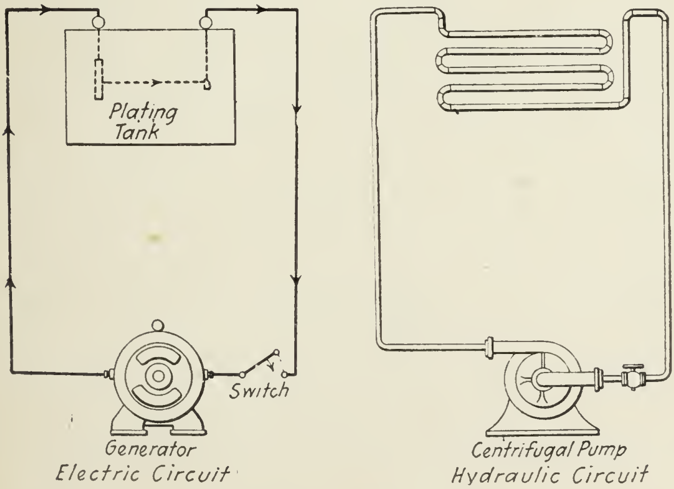


Fig. 2.—Comparison of Electric and Hydraulic Circuits

hydraulic circuit. The switch and stop-cock serve identical purposes; they control the flow of electricity and water respectively. The plating tank offers resistance to the flow of current in the electrical circuit, while a series of cooling coils, perhaps, retards the flow in the hydraulic circuit.

THE AMPERE

As an aid in defining the various units of electrical measurement, this analogy of the passage of an electric current through a wire and the flow of water in a pipe may again be cited. The quantity of water flowing through a pipe in a specified time is usually measured in gallons. In like manner the quantity of electricity flowing through a wire in a given period is expressed in amperes. The gallon and the ampere, then, are both units of quantity measurement. A more technical definition of the ampere is: ''the practical equivalent of the unvarying current which, when passed through a solution of nitrate of silver in water (in accordance with standard specifications), deposits silver at the rate of 0.001118 gram per second.'' It is also interesting to note that in accordance with the second law of Faraday, this same current would deposit approximately 0.0003287 gram of copper in one second.

THE VOLT

Again referring to the water pipe illustration, the difference in hydrostatic pressure between two points in the system is expressed in pounds per square inch. In the electric circuit the difference in pressure, or potential, between two points is measured in volts.

POTENTIAL DIFFERENCE

Refer to Fig. 3, illustrating analogously the similarity between pressure drop and potential difference at various points in the system. When the stop-cock is closed so that no water flows, the pressure gages all indicate the same reading. In like manner, the voltmeters in the electric circuit all show the generator terminal voltage when the switch is thrown, so that no current flows. Open the stop-cock, and a uniform drop in pressure is noted on the gages, A showing the highest reading and D the lowest. The same condi-

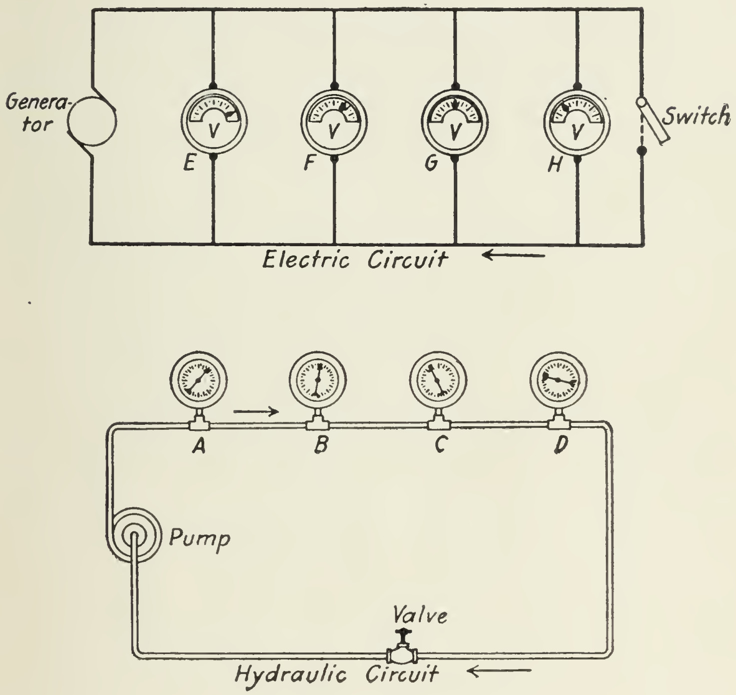


Fig. 3.—Fall of Potential and Fall of Pressure

tions exist in the electric circuit; when the current is flowing, the voltmeter, F, indicates a lower reading than the meter E, G lower than F, and H the lowest of all. The difference between the readings at E and H is termed the difference of potential.

THE OHM

Because no substance is a perfect conductor of electricity, a percentage of the electric energy is changed during transmission to some other form, usually heat. This transformation is caused by the resistance the substance presents to the passage of the electric current. This resistance of any substance is expressed in units termed ohms and is definitely known by comparison with the standard measure of resistance. This standard unit or ohm is the resistance, at 0° Centigrade, of a column of mercury 106.3 cm. long, having a cross-section of 1 sq. mm.

RESISTANCE FACTORS

There are several conditions that influence the resistance of a conductor, such as material, cross-section area, length, and temperature. It is readily understood that the amount of resistance varies with the nature of the substance. Copper, for instance, is an excellent conductor of electricity. On the other hand, iron shows a resistance six times that of copper, while the resistance of mercury measures about sixty-four times as great. Electrical resistance also varies inversely as the area of the cross-section of the conductor. In the case of a round wire, the resistance varies inversely as the square of the diameter. This is seen at a glance by referring to tables showing wire sizes and the corresponding resistances per unit length. Further, provided the material and cross-section of a conductor remain constant, the resistance varies directly as the length. This means that all other values being equal, a wire 50 feet long has twice the resistance of a section 25 feet in length. The fact that the resistance of a conductor changes as its temperature varies is of especial interest to the electroplater. Metals show an increase in electrical resistance when their temperature is raised. As exceptions to this law, carbon and electrolytes show a decrease in resistance to the passage of an electric current when the temperature is increased. This is why it is so essential to keep the plating bath at a comparatively high temperature by artificial heating.

There is a definite relationship between the resistance, current strength, and potential difference or electro-motive force, known as Ohm's Law. Expressed in the form of an equation, $I=E/R$, where I is the current strength in amperes, R is the resistance in ohms, and E is the electro-motive force in volts. Thus, it is readily seen that to increase the flow of current in an electric circuit, either the voltage must be increased or the resistance decreased. In plating work, the current is usually regulated by controlling the resistance of the circuit by a rheostat. This method is discussed in another chapter.

Other convenient forms of the first equation are: $E=IR$, i.e., the electro-motive force, is equivalent to the product of the current value in amperes and the resistance expressed in ohms.

Or, again, $R=\frac{E}{I}$

If any two of the three values are known, the third is easily computed through the use of the foregoing equations.

SERIES CIRCUITS

When several resistance units, such as R_1, R_2, and R_3, are connected in series as indicated in Fig. 4, the total resistance of the three units is the arithmetical sum, or $R_1+R_2+R_3$. Obviously, the current has the same value at any part of the circuit, since there is but one path to follow. Moreover, since the current flowing through all units is identical, then the difference of potential across each unit is directly proportional to its resistance. For example, $E_1=R_1I$, or $E_3=R_3I$. Note that if a break occurs at any point in the circuit, the current flow through all units ceases.

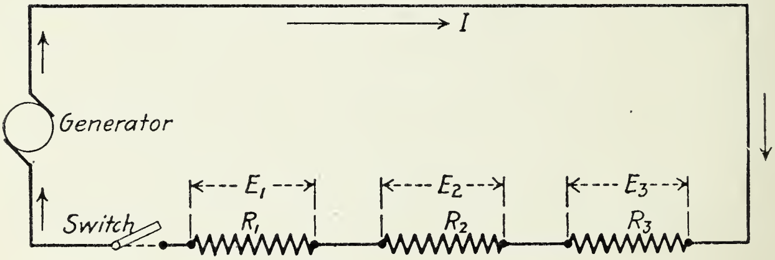


Fig. 4.—Three Resistances in Series

PARALLEL CIRCUITS

On the other hand, if the resistance units are connected in parallel or multiple, as shown in Fig. 5, the total resistance is not the sum of the three, nor do the currents flowing through the different units have the same value. Parallel circuits are of especial interest to the electroplater, since the tanks he uses are in reality resistance units connected in the circuit as indicated in Fig. 6.

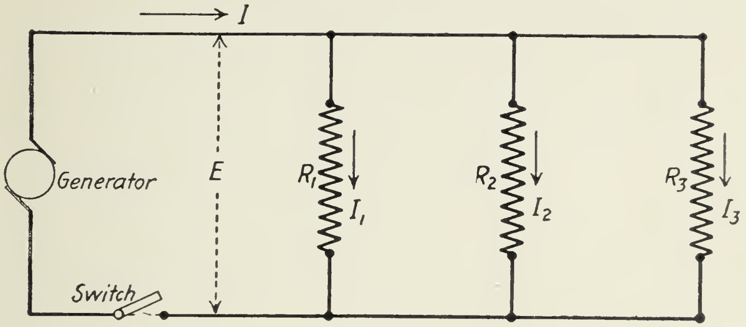


Fig. 5.—Three Resistances in Parallel

Let us consider the subject through the assistance of equations. I is the total current generated and E is the line voltage. By referring to the diagram

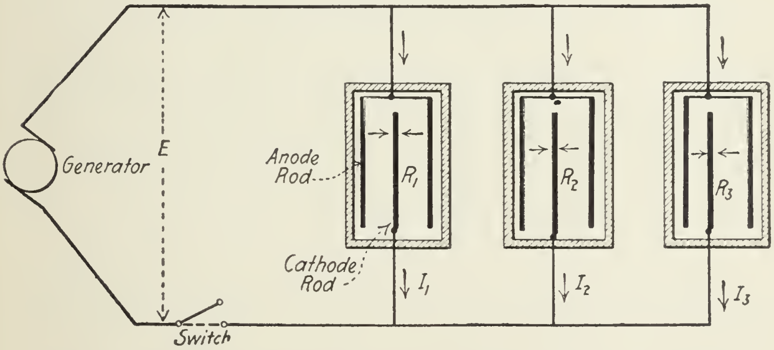


Fig. 6.—Three Plating Tanks Connected in Parallel

again, it is noted that the potential difference across any unit is E, regardless of the resistance. The value of E, then, is the constant in all of the following equations. The resistance of the three units may be considered as R_1, R_2, and R_3, while the value of the current flowing in each is I_1, I_2, and I_3, respectively. R is the total resistance, which is, of course, less than that of any of the individual units.

Then
$$I=\frac{E}{R}$$

But
$$E/R=E/R_1+E/R_2+E/R_3$$

Eliminating E, we find the reciprocal of the resistance, termed the conductance, is

$$1/R=1/R_1+1/R_2+1/R_3$$

The equation may be used in this form, but it is usually more convenient to complete it. Thus,

$$R=\frac{R_1+R_2+R_3}{R_1R_2+R_2R_3R_1+_3}$$

Should it so happen that all of the units had the same resistance as R_1, for instance, then

$$R=\frac{R_1^3}{3\,R_1^2}=\frac{R_1}{3}$$

Knowing the resistance of any unit, it is a simple problem to determine the current flowing in that branch:

$$I_1=\frac{E}{R_1}$$

Again, using a voltmeter and an ammeter, the value of E and I_3, for example, are quickly found. And

$$R_3 = \frac{E}{I_3}$$

Note that disconnecting any one or two of the resistance units in parallel or multiple does not open the complete circuit; only the current value increases in the remaining branch or branches.

THE COULOMB

That quantity of electricity which, when passed through a silver nitrate solution, deposits 0.001118 gram of silver, is termed one coulomb. This definition is, perhaps, more easily understood when it is stated: a coulomb is the quantity of electricity produced by one ampere flowing for one second.

THE JOULE

The unit of work is the joule. It is the work done per second by one ampere flowing through a circuit under a pressure of one volt. In other words, the product of the current in amperes, potential difference in volts, and the time in seconds, is expressed in joules.

THE WATT

The watt is the power developed by one joule per second, i.e., one volt-ampere. The kilowatt, or 1,000 watts, is usually employed in commercial measurement of power.

It is interesting to note the several methods of determining the power developed in a circuit. If W is taken as the symbol for the watt, then

$$W = EI$$

But in a preceding paragraph it was learned that

$$I = \frac{E}{R}$$

Hence, $$W = E \times \frac{E}{R} = \frac{E^2}{R}$$

Or again, $$E = IR$$

Thus, $$W = I \times IR = I^2R$$

This last equation is quite important and is often used to determine the power lost in the form of heat in a circuit whose resistance is known.

THE WATT HOUR

Because the joule is too small a measure of electrical energy, a larger unit, the watt hour, is employed. The kilowatt hour is used commercially in the measurement of electric power. The term is self-explanatory and requires no definition.

THE HORSE-POWER

Power-producing engines or motors are usually rated by their horse-power capacity. Mechanically the horse-power is equivalent to lifting 550 pounds a distance of one foot in one second, or 33,000 foot-pounds per minute. One horse-power is equivalent to 746 watts. This conversion factor, 746, is important, since generator capacity is usually expressed in kilowatts, and to determine the horse-power of the driving unit the conversion factor is employed.

CHAPTER III

THE LOCATION AND CONSTRUCTION OF THE PLATING ROOM

Three Factors—The Individual Shop—The Factory Department—General Requirements—Floor Plan—Generator Location—Floor Drainage—Wooden Floor Construction—Acid Proof Walls—Ventilation—Illumination—Heating.

THREE FACTORS

In these days of keen business competition, the success of any enterprise depends, in a large measure, upon the site of operations, upon efficient equipment, and upon contented, loyal employees. The electroplating industry is no exception; efficient management will demand these as prerequisites. The first two factors may be discussed here, but the third is a personal issue, and therefore not within the province of this book.

THE INDIVIDUAL SHOP

If an electroplating business is to be successful, the shop must be so located that prospective customers can reach it without undue effort or expense. It is not necessary to secure a site in the congested business section where high rents prevail, but a location approximately equidistant from all of the sources of trade is advisable. Facilities for handling large quantities of commercial work should include, aside from the plating and polishing operations, adequate space for storage, packing, and shipping. Again, providing for the future, sufficient floor area for business expansion should be secured.

THE FACTORY DEPARTMENT

Even though the plating room be but a department in a large factory, the same attention to its location in relation to the other divisions is necessary. Study the machining operations which precede the plating work; consider the routing of each part that must pass through the plating and polishing rooms. For instance, if it is observed that the final machining operations on the major portion of the factory output is that of drilling or counter-sinking holes, endeavor to locate the plating and drill-press departments in close proximity. Perhaps, on the other hand, it is found that most of the small punch press parts pass through the plating room before being sent to the assembly floor or finished parts storeroom. Should these punched parts outnumber the articles coming from other departments, then the obvious location for the plating division is in the direct path from the punch shop to the assembly floor or storeroom. Such elimination of trucking saves both expense and production time.

GENERAL REQUIREMENTS

Since it is often quite difficult to prevent leaks in the floor, even though it is carefully waterproofed, a ground level location is suggested. Good natural lighting increases the efficiency of the workmen and incidentally prevents eye-strain. A further factor pertaining to the welfare and health of the operator is fresh air. If it is not possible to utilize large roof ventilators, resort must be had to motor-driven fans for the removal of poisonous fumes from the atmosphere. A water, steam, and compressed-air supply should be available, if possible. Further discussion of this last point will appear later.

FLOOR PLAN

Obviously, it is not possible to present a definite floor plan of a plating room equipped to meet all the varied requirements of the trade. The plater must study his business needs and outline the equipment accordingly. A suggested plan, however, is shown in Fig. 7. This indicates two nickel tanks, one zinc tank, a copper and a brass tank, as well as two plating barrels. These latter are used to advantage for plating small articles, such as screws, nuts, and washers. The tanks are, of course, adapted to larger work. Vats for gold and silver plating may replace any of those mentioned, or, if necessary, may be added to the group. The cleaning and scouring boards are centrally located to minimize walking distance. The dips are situated across the room from the tanks, so what fumes may escape from the ventilating hood will not affect the men working at plating. Articles removed from the dip may be plunged in the hot water, dried in the sawdust, and placed in the oven without retracing steps.

GENERATOR LOCATION

The generator should be placed as near as convenient to the plating tanks. The essential reason

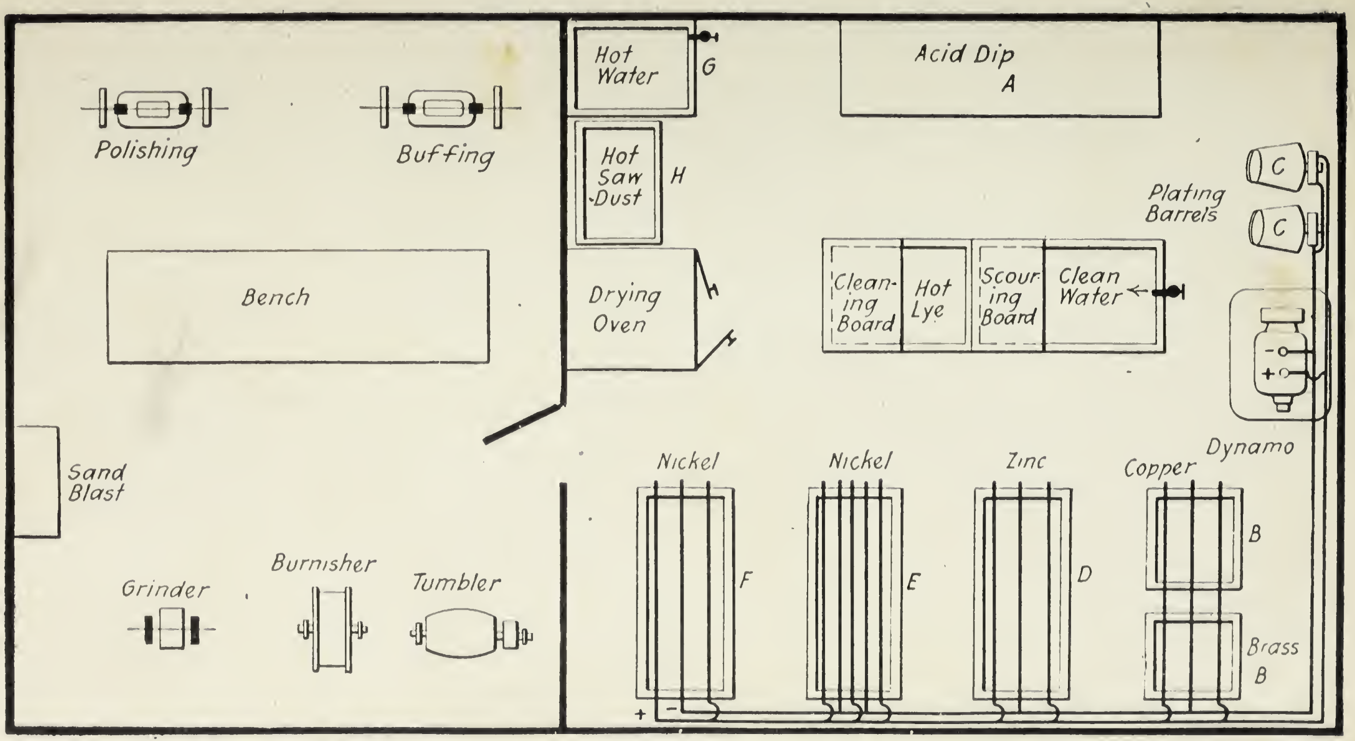


Fig. 7.—Suggested Floor Plan for Plating and Polishing Room

for this is to prevent a drop in potential or voltage between the generator and the tank rods. A further result of this will be the saving in the cost of the heavy copper conductors. Under no circumstances should the machine be located in the grinding or polishing rooms, unless the bearings and commutator are fully protected from the gritty dust which is usually floating in the air. Indeed, if space will permit, it is advisable to install the generator outside the plating room. The acid fumes, even though the windings are impregnated, often attack the insulation. It must be remembered that the generator requires a certain amount of attention if satisfactory results are to be obtained; an inaccessible location, such as the ceiling, should not be chosen.

FLOOR DRAINAGE

Upon the floor construction depends the health of the employees; a damp, poorly drained walking surface is the cause of much discomfort. If possible, a concrete surface should be laid with a slight slope toward a central tile drain. This concrete surface need not be more than five inches thick at the heaviest point, nor more than two inches at the drain. If it is essential that no moisture leak through any possible cracks that may form, further precautions are necessary. Two layers of a good roofing paper should first be laid, the strips of the first layer at right angles with those of the second. Several coats of asphaltum paint between the layers, as well as upon the top surface, are required to make an acid and moisture proof seal.

WOODEN FLOOR CONSTRUCTION

While the concrete work just described may serve as a floor surface, much greater satisfaction results from the use of an additional wooden platform, such as is shown in Fig. 8. Since the tank and vat foundations rest directly upon the concrete base, it is only necessary to provide the superstructure for the spaces between them. These small platforms, such as A, B, C, are approximately 5 feet square. The small dimensions are suggested, since the sections may then be quickly and easily removed at any time for cleaning or repairing work. The platform is not solid, but is constructed of heavy slats, thus allowing spilled water or acid to pass through to the concrete base where it flows to the drain. The advantage of this type of floor is apparent; it gives the electroplater the driest possible walking surface.

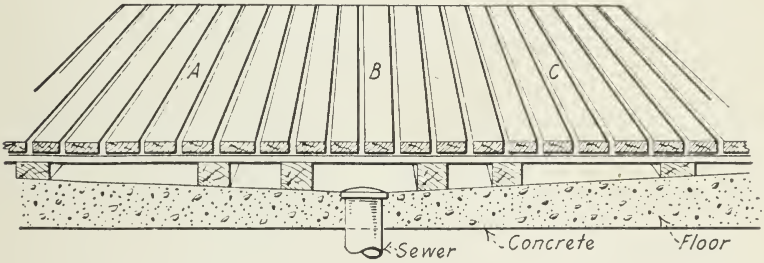


Fig. 8.—Cross Section, Showing Floor Construction of Plating Room

ACID PROOF WALLS

If it is desired to protect the lower walls of the plating room from acid and water stains, a protection similar to that indicated in Fig. 9 is suggested. This consists of a wooden frame-work standing four or five feet high and about two inches from the wall. It is covered with roofing paper, the lower edge turned with the slope of the floor as shown, to throw the acid or water toward the drain. If the framework and the dipping or pickling tanks adjoin each other, several coats of asphaltum paint are required to serve as a further protection against acid. It is a good plan to install the air, steam and water pipes behind this structure. On the other hand, it is not advisable to pass any electrical circuits through the space thus provided, since they should be as accessible as possible.

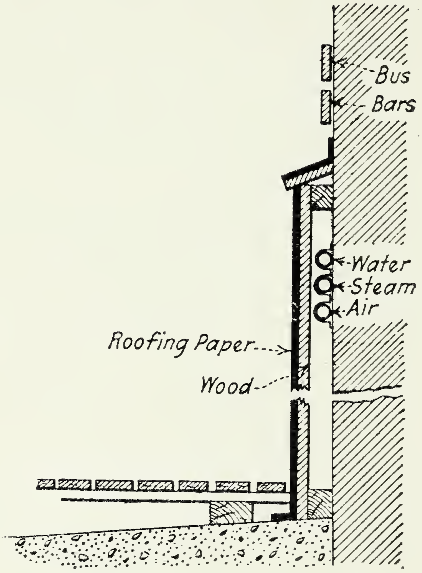


Fig. 9.—Cross Section, Showing Framework for Protecting Wall of Plating Room from Damage by Acid

VENTILATION

Undoubtedly, there is nothing quite so priceless as good health, and the electroplater is cautioned against endangering this asset by working in a room filled with poisonous fumes. Advantage should, of course, be taken of natural ventilation through windows and roof openings. If possible, the movement of the air should be accelerated by the use of power-driven fans. Over all tanks or vats whose contents give off objectionable vapors, hoods should be suspended and the fumes collected by these hoods drawn off through sheet-metal pipes by a ventilating fan. The hoods are usually constructed of sheet iron, but wood can be used. Several coats of asphaltum or other acid-resisting paint should be applied as a protection from chemical action. In the ventilating system shown in

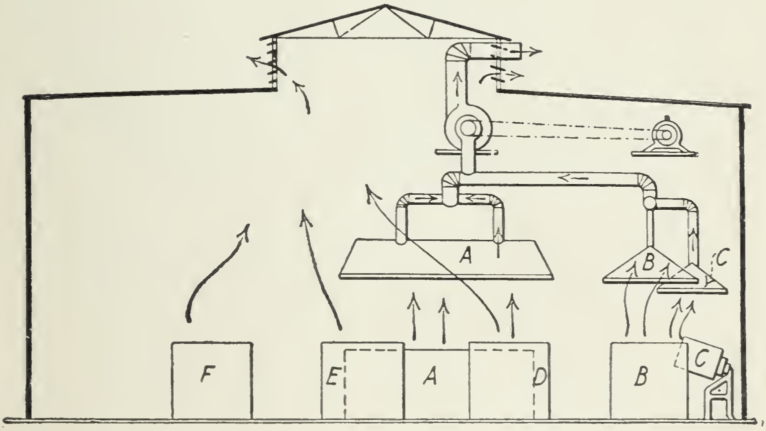


Fig. 10.—Natural and Forced Ventilation. Hoods are Placed Over Tanks A, B, and C. Refer to Fig. 7

Fig. 10, a hood, A, is placed over the dipping vats, one, B, over the copper and brass tanks, and another, C, above the plating barrels. The fan and the driving motor should be located as near to the outlet as possible. Either or both can be suspended from the ceiling or secured to wall supports.

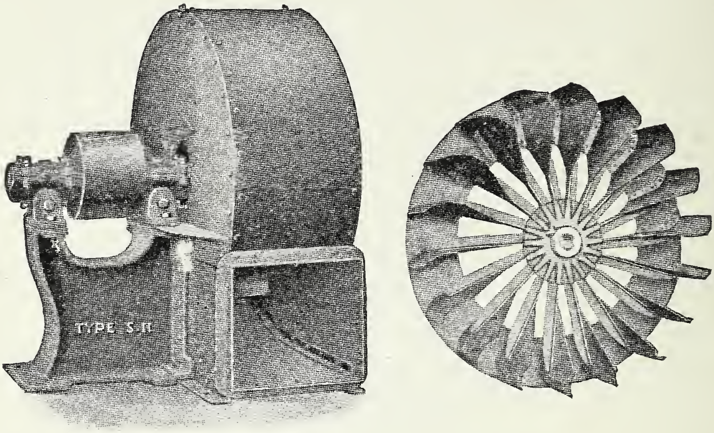


Fig. 11.—Exhaust Fan for Forced Ventilation

(Mott Sand Blast Mfg. Co.)

ILLUMINATION

The electroplater is often so interested in studying modern plating methods and so intent upon improving the electrical and tank equipment, that a very important item escapes his attention. This item is proper illumination, without which efficient and perfect work cannot be accomplished. During the summer months it is seldom necessary to supplement daylight with artificial illumination. For winter, or on a foggy, cloudy day, there are many hours when the electric light is required. At night, of course, artificial illumination is a necessity.

There is, perhaps, but one suggestion to be made on the use of daylight. If the tanks be located so that the cathode rods lie at right angles with the plane of the window, it follows that the plater, while working, will never stand in a position to cast his shadow over the tank. Furthermore, no equipment

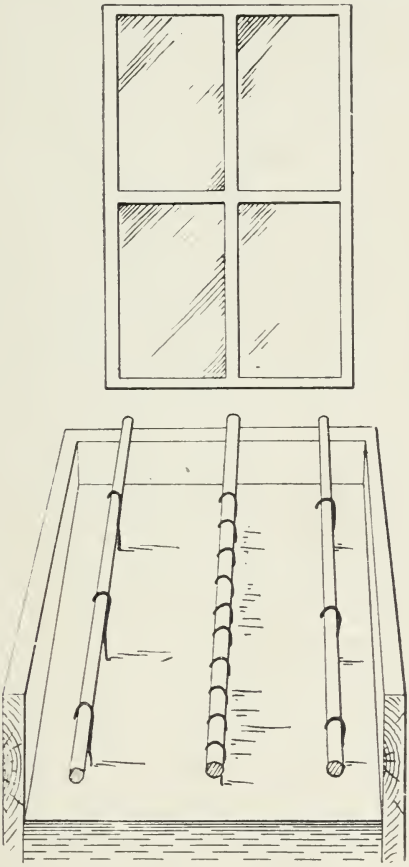


Fig. 12.—Natural Lighting. Note the Relative Location of Tank and Window

should be placed in such position as to screen the light or throw a shadow on the plating work. Note, in Fig. 12, the correct relative position of tank and window.

With artificial lighting the tank location is not as important as the position of the lamps. A quantity of correctly spaced lamps of low candle power is much to be preferred to a single large unit. The latter prevents concentration, since the eyes involuntarily fix themselves on the bright spot; moreover, with a high candle power lamp, the shadows are denser and, therefore, misleading. If it is not possible to suspend a light above each tank or bench, the units should be equally spaced and hung above the working plane. By referring to Fig. 13, the meaning of this will be apparent. While the lamp B, hung just above the head of the workman, provides little illumination for the tanks, C allows light for both tank and floor, and also eliminates distracting shadows. A height of

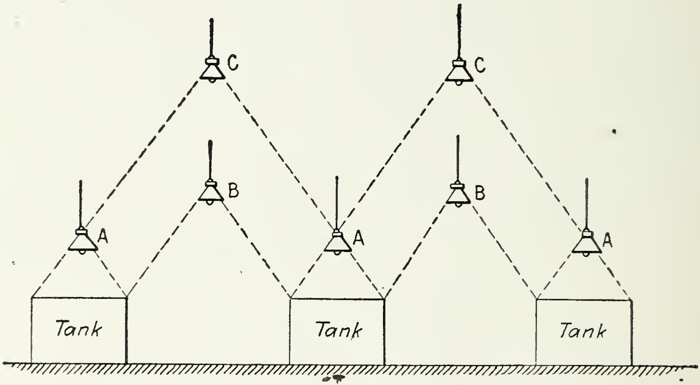


Fig. 13.—Artificial Lighting, Showing Correct and Incorrect Lamp Spacing

12 to 14 feet above the floor is usually found to be best.

HEATING

Because of the presence of acid vapors in the plating room, the air is changed many times a day through the use of some type of ventilating system. During the cold winter months the heating problem, because of the need for the excessive ventilation, is a serious one. Obviously the best solution is to add more heating units, whether they be steam radiators or stoves. Again, if arrangements are made so that the incoming cold air is admitted where the fumes are heaviest and the exhaust strongest, the remaining part of the room is then comparatively free from draughts.

CHAPTER IV

ELECTRICAL EQUIPMENT FOR THE PLATING ROOM

Current Supply—The Generator—The Electro-Magnet—The Field Magnet — Four Types — Series Generator — Shunt Generator—Compound Generator—The Separately Excited Shunt Generator—The Armature—The Commutator—The Armature Winding—The Brushes—The Bearings — Capacity — Location — Driving Unit — Motor Capacity—Motor Speed—Generator Voltage Regulation—Generator Field Rheostat — The Ammeter — The Voltmeter—The Amperehour Meter—Tank—Rheostat—Two-Wire System—Three-Wire System.

CURRENT SUPPLY

Modern plating methods do not include the use of the primary battery as the chief source of the electric

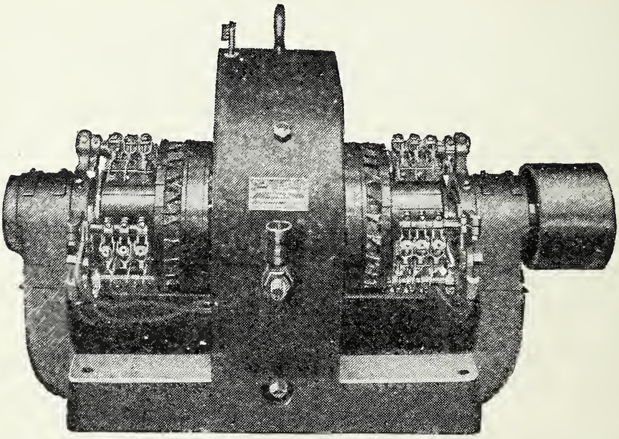


Fig. 14.—1500 Ampere, 6 Volt Plating Generator

(Bennett O'Connell Co.)

current supply; the more reliable and efficient power-driven generator has replaced it. The chemical battery, except for quite small shops or for experimental work, is no longer considered in the planning of plating equipment, and therefore no space will be given here to a discussion of the existing types.

THE GENERATOR

A well-designed and carefully constructed generator is, perhaps, expensive, yet the plater can ill afford to purchase a machine which, though cheap, is fabricated from inferior material and by questionable mechanics. Careful consideration should be made of the requirements, and these then compared with the advertised characteristics of the generators on the market. Too much caution cannot be exercised in making the selection, for upon the uninterrupted service of the machine depends the success of

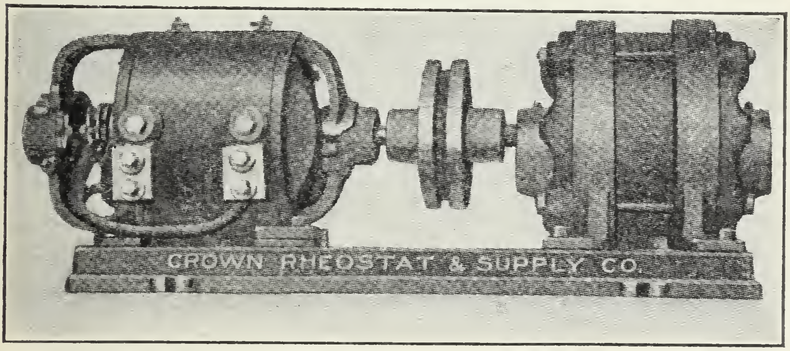


Fig. 15.—Direct Connected 300 Ampere, 6 Volt Plating Generator

(Crown Rheostat & Supply Co.)

the output. Should the generator fail every plating operation must necessarily cease, while the overhead expense of the shop continues. It is advisable, therefore, to consider carefully the construction, characteristics, and operations of the several types of generators. The illustration in Fig. 15 shows a direct connected 300 ampere plating generator and that in Fig. 16 outlines a double commutator generator for large current output.

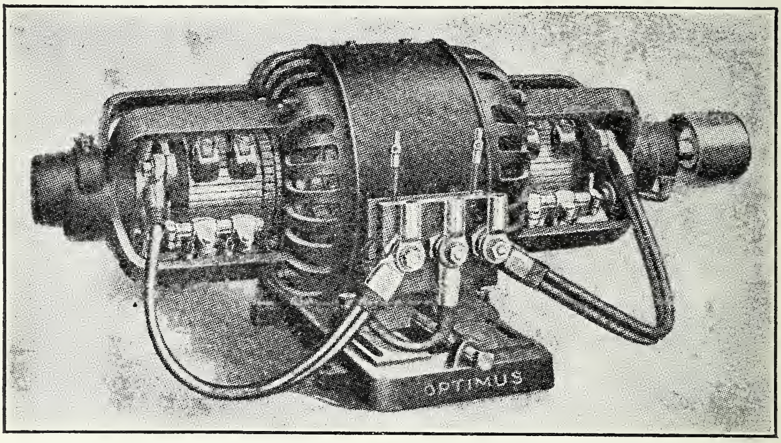


Fig. 16.—Double Commutator Generator. Capacity: 750 Amperes at 6 Volts or 375 Amperes at 12 Volts.

(A. P. Munning & Co.)

THE ELECTRO-MAGNET

Undoubtedly the best method of approaching a description of the generator is to briefly review the elementary principles of the electro-magnet. The hardened steel horseshoe magnet is a familiar toy to all of us. Similar magnetic properties are given to a soft iron rod, around which a wire, carrying an electric current, is wound. The polarity of the solenoid or electro-magnet is dependent upon the direction of current, and is determined by so grasping the coil of wire with the right hand, that the fingers point in the direction the current is passing. The north pole of the solenoid is then at that end of the rod toward which the outstretched thumb, at right angles to the fingers, is pointed. This method is known as the "right hand rule." Note Fig. 17.

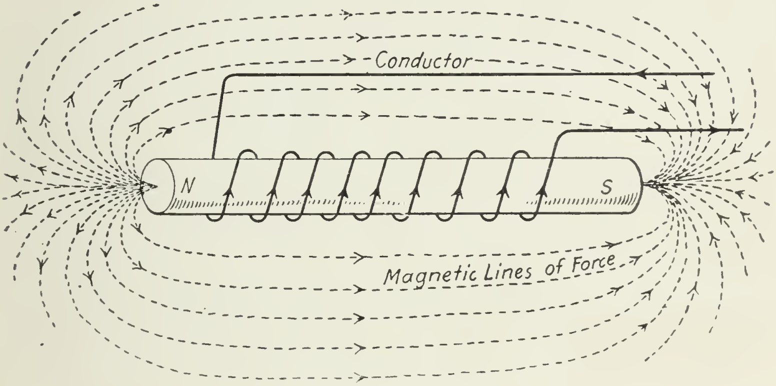


Fig. 17.—Electro Magnet, Showing Direction of Current Flow in Winding and Resultant Polarity

THE FIELD MAGNET

The field magnet of a dynamo is quite similar to the solenoid just described. A four-pole generator, for instance, might be constructed from four electro bar magnets, the ends of which have been formed as in Fig. 18. The adjacent placing of the like poles produces four poles instead of eight. A more convenient and less costly method of construction is employed, however, in commercial practice. A circular or rectangular iron yoke is provided with poles, the wire being wound on the latter, as indicated diagrammatically in Fig. 19. Any number of poles in multiple of two may, of course, be provided to agree with the design.

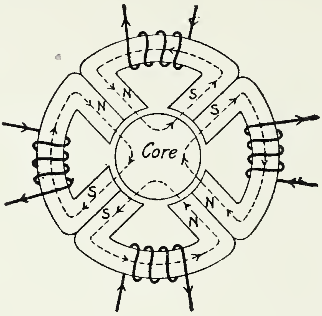


Fig. 18.—Four Solenoids Bent and Placed Together to Form a Four Pole Dynamo Field

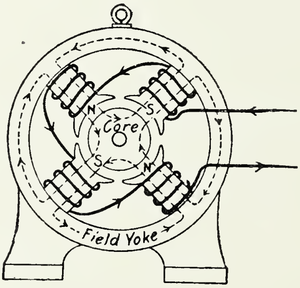


Fig. 19.—Field Winding and Magnetic Circuit of Dynamo

FOUR TYPES

In general, there are four types of direct current producing dynamos, or more exactly termed generators, and these take their names from the method of field winding or excitation. These types are: Series, shunt, compound, and separately excited shunt.

SERIES GENERATOR

The stator or field of a series generator has a low resistance winding, since the full line current passes through it. It is, therefore, usually wound with a few turns of heavy copper wire or strip. Since the current regulation of a generator is mainly dependent upon its field excitation, a variable resistance is placed in parallel with the field winding, as shown in the conventional diagram, Fig. 20. However, on account of the very large current required for plating work, the series type generator is seldom specified for such use.

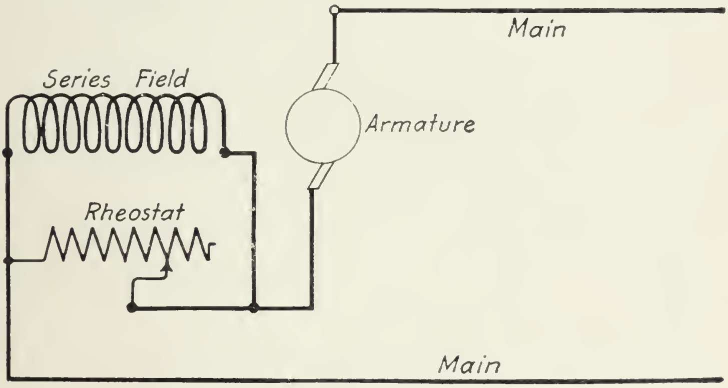


Fig. 20.—Connections for Series Generator

SHUNT GENERATOR

As the name implies, the field winding of the self-excited shunt type generator is shunted or paralleled with the line circuit. Of necessity, this winding must have comparatively high resistance, and therefore a large number of turns of fine wire is wound on the field magnets. To adjust the field current, a variable rheostat is connected as indicated in Fig. 21. Since so small a percentage of the current output of the generator is required to excite the field, the rheostat need not have the capacity required for the series type machine. The shunt generator, when the driving speed does not vary, maintains an almost constant voltage. It is, therefore, used for plating when the output required is small.

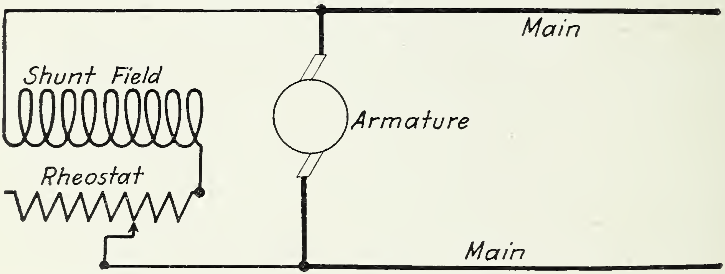


Fig. 21.—Connections for Shunt Generator

COMPOUND GENERATOR

Where plating currents of 2,000 amperes or less are required, the compound wound generator usually proves most efficient. It retains the desirable features of both the shunt and series winding. A shunt winding is employed and its terminals connected, through a rheostat, to the brushes. Over this is wound a few turns of heavy wire or metallic strips, which are connected in series with the line circuit. Fig. 22 shows this in conventional form. The voltage regu-

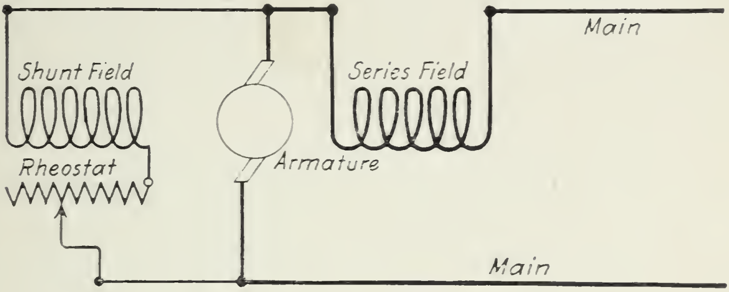


Fig. 22.—Connections for Compound Generator

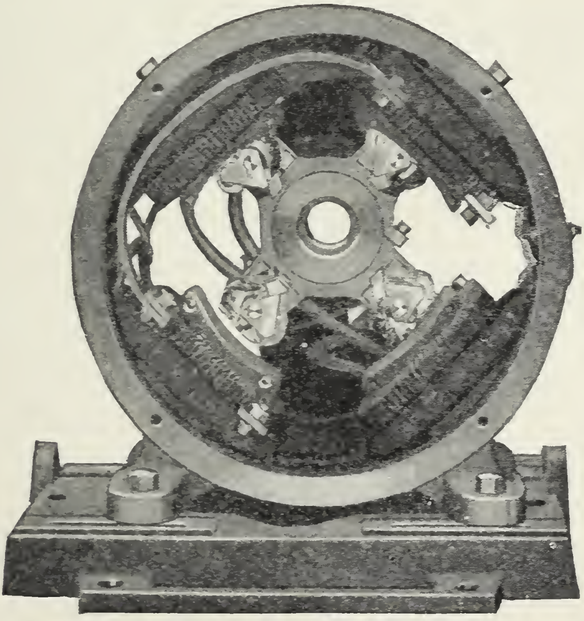


Fig. 23.—Generator Frame, Showing Field Coils and Position of Brush Holders. Compound Wound

(Crown Rheostat & Supply Co.)

lation of this machine is accomplished with less difficulty than is that of the shunt type. Even though the current output varies, as is often the case when work is placed in or removed from the tanks, an approximately constant voltage is obtained, provided the driving speed does not vary.

THE SEPARATELY EXCITED SHUNT GENERATOR

Generators, designed and built to deliver a current output in excess of 2,000 amperes, are usually of the shunt type, the field coils being connected to a separate source of direct current supply. Quite often a small generator, driven by the same unit that turns the larger machine, is employed. The field excitation is regulated in much the same manner as that previously described for the shunt generator. Note Fig. 24.

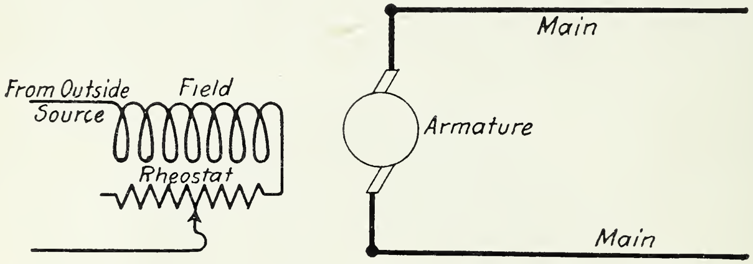


Fig. 24.—Connections for Separately Excited Generator

THE ARMATURE

The armature is that part of the generator which rotates within the magnetic area produced by the field magnets. No space can be given here to all of the interesting fundamental principles involved in the production of an e.m.f. Briefly, when a wire is passed through a magnetic field so that it cuts the lines of force at right angles, an e.m.f. is set up between the ends of the wire. Thus, if a wire is mounted on a drum, as indicated in Fig. 25, and the latter revolved between the field magnets, a current flows in the wire or circuit each time it passes a pole where it cuts the magnetic flux. If the ends of the wire are connected to two simple metallic rings, which are insulated from each other and from the shaft, so that connections may be made through brushes to a two-way voltmeter, a strange thing is noticed. When the armature wire passes the north field pole, the voltmeter pointer swings in one direction, but quickly reverses, passes the zero point, and swings an equal distance in the opposite direction as the south pole magnet is approached and passed. This voltmeter movement clearly indicates that the direction of current flow in the armature coil is dependent upon the

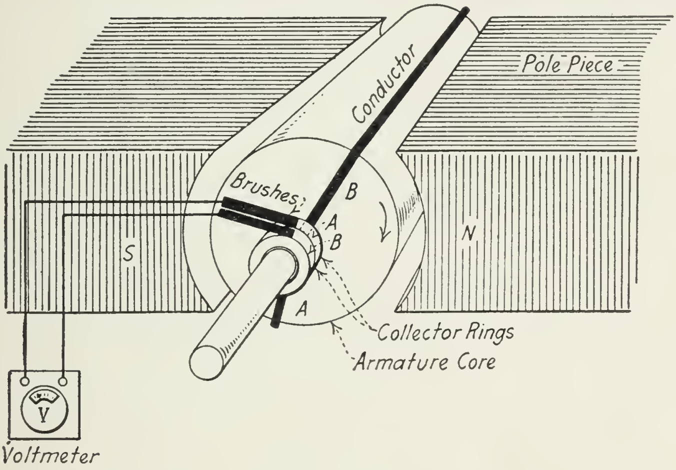


Fig. 25.—Single Conductor, Each End Connected to Individual, Insulated Metal Collector Ring

polarity of the pole past which the wire is rotated. If current pressure readings could be taken for each degree of the complete cycle, as indeed they may be with special experimental apparatus, the plotted e.m.f. curve might appear similar to that shown in

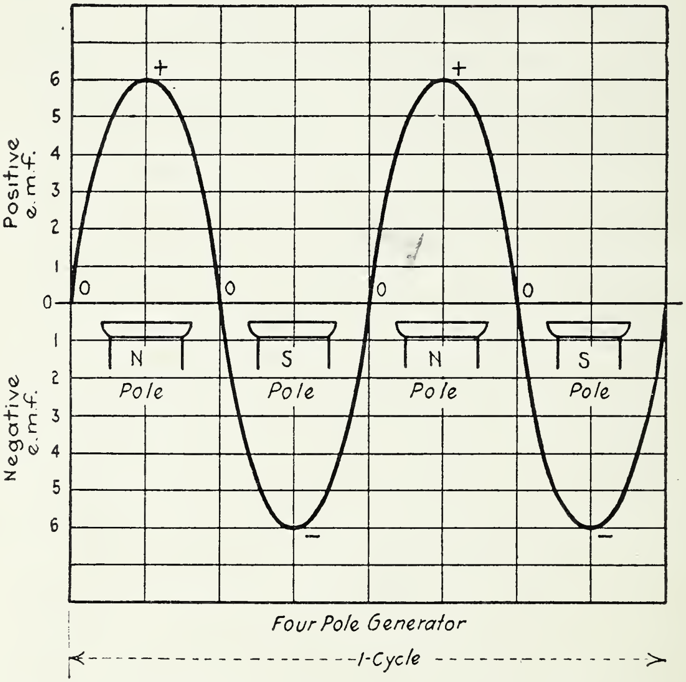


Fig. 26.—No Commutation: Alternating Current

Fig. 26. For electroplating work, alternating currents cannot be employed, since a uni-direction current is necessary to carry the metal ions toward the cathode only. A later paragraph will discuss a method of securing positive current values.

In general, the generator armature is constructed from an assembly of three units: the shaft, the spider, and the core iron. The shaft is, of course, turned from high grade steel. Its length and other dimensions are determined by the design of the generator. The core iron is punched from thin sheets of iron having special magnetic characteristics. The thin laminæ are slotted to receive the armature coils, and insulated to a certain degree by painting to prevent eddy currents in the assembled core. The core iron is placed over the machined cast-iron spider, where it is bolted tightly in position. In this assembly precautions are taken to provide for ventilating ducts whose function it is to prevent overheating. The spider and core assembly are finally pressed on the shaft.

THE COMMUTATOR

In plating work, alternating current, such as that just described, cannot be used; the current must flow

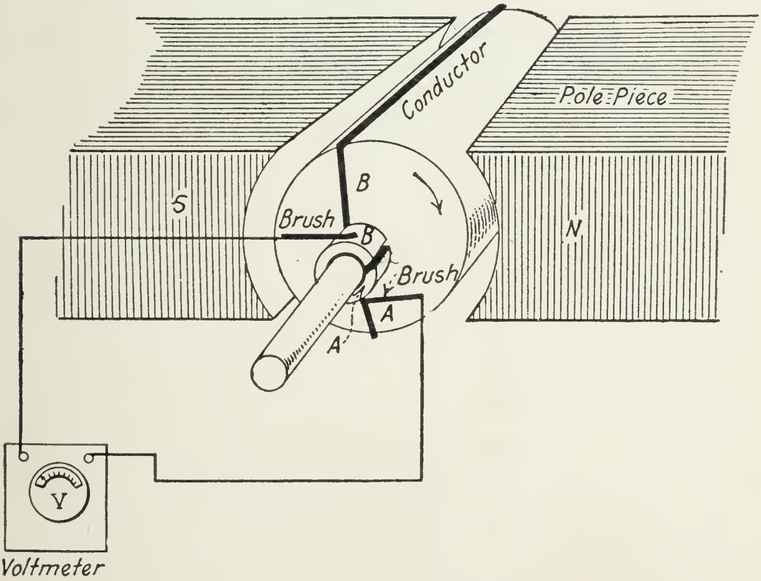


Fig. 27.—Single Conductor, Each End Connected to Separate, Insulated Commutator Segment

in one direction only. Thus, instead of slip rings for collecting the current, a device to commutate or change the current direction at the moment it is about to become negative in value is employed. A commutator for a single circuit, as shown in Fig. 27, would be in but two sections, thus allowing the brushes to interchange their connections with the rings at the points where reversals of current are about to take place. The addition of a commutator changes the e.m.f. curve of Fig. 26, so that only positive values are given as in Fig. 28.

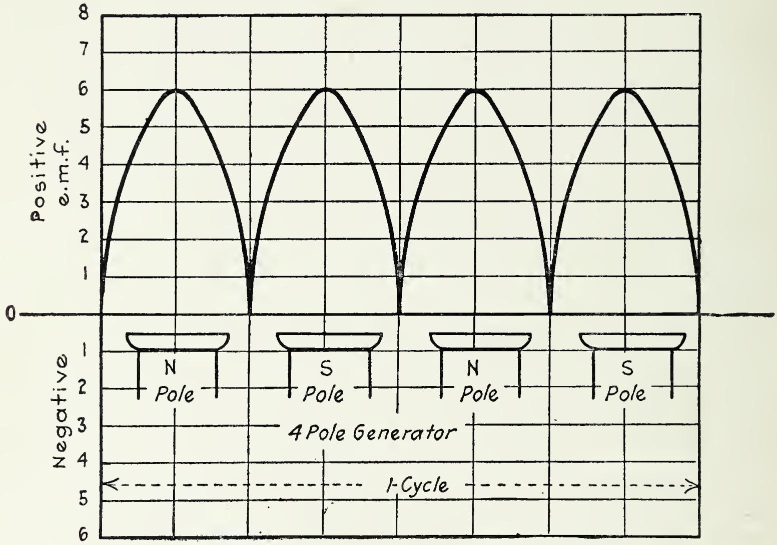


Fig. 28.—The Effect of Commutation is to Produce Direct Current

Obviously, the e.m.f. generated by a single wire is insufficient for practical purposes. Hence, the modern dynamo has an armature wound with a great many wires. A large number of such active wires are so connected that their voltages are accumulative. Again, since the wires are evenly distributed about the drum, or armature core, the commutator is constructed of many segments which are connected to the winding at regular intervals. This allows an almost constant voltage across the brushes, ironing out, so to speak, the humps in the curve of Fig. 28, and giving an approximately straight, horizontal voltage line.

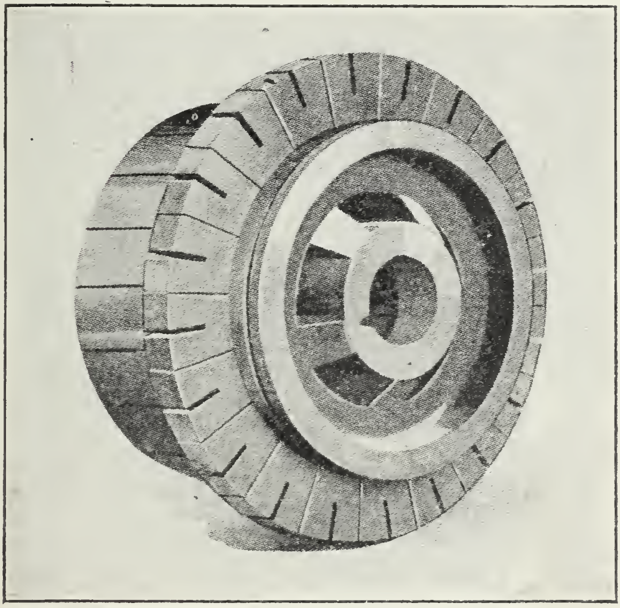


Fig. 29.—Commutator Assembly

(Bennett O'Connell Co.)

The commutator is usually built up of especially formed copper segments, insulated from each other by mica pieces. The mica and copper segments are held rigidly together by heavy iron flanges pressed in position. This construction is shown in Fig. 29.

THE ARMATURE WINDING

The armature conductors are usually formed of heavy copper strip insulated with a cotton covering. There are several types of windings used for generators, and for a further discussion the reader is referred to the many available texts on dynamo design. Before the windings are placed in the slots, the latter are usually insulated with cloth and paper of high electric strength. Often wooden or fiber slot wedges are used to securely lock the coils, preventing their movement when the armature revolves.

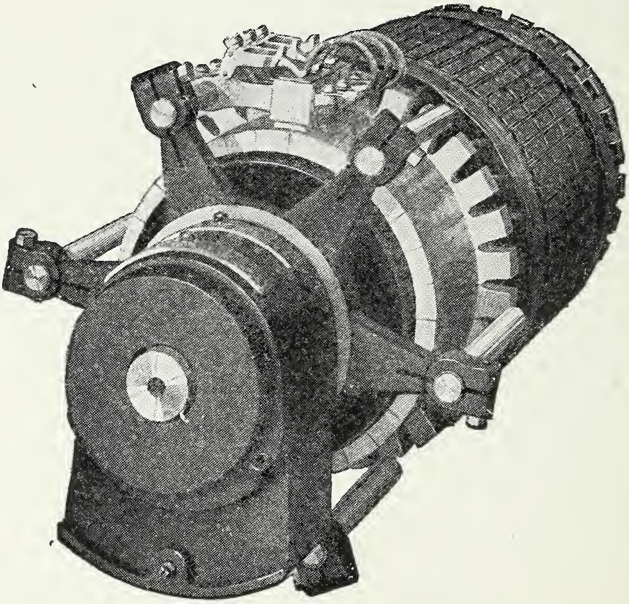


Fig. 30.—Brush Rigging and Armature Assembly

(Bennett O'Connell Co.)

THE BRUSHES

There are as many brushes as poles, and in practice they are usually set slightly in advance of the latter. Specially designed brush holders, similar to that shown in Fig. 31 are provided. Because of the low voltage required in plating work, low resistance brushes are essential. Carbon has a high resistance, and is therefore not a suitable material for such brushes. Metallic composition brushes, however, of

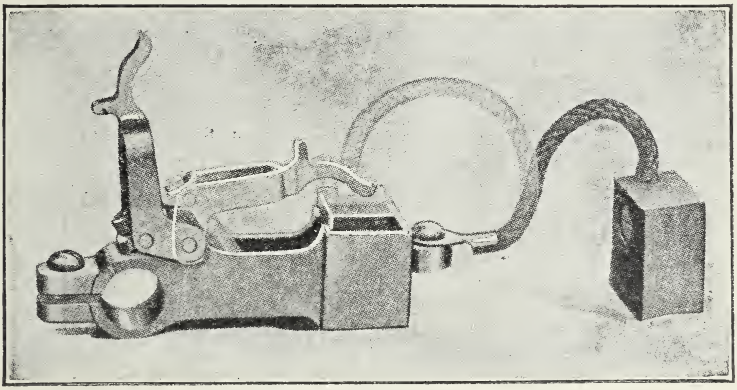


Fig. 31.—Brush Holder and Brush

(Bennett O'Connell Co.)

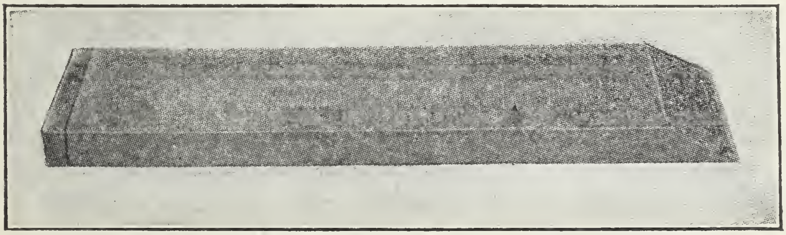


Fig. 32.—Woven Wire Brush for Plating Generators.

(Hanson & Van Winkle Co.)

which there are several types on the market, appear to give excellent results. A typical woven wire brush for plating generators is shown in Fig. 32.

THE BEARINGS

Most modern generators are equipped with bronze or other non-frictional metal bearings. Lubrication is effected by means of oil rings revolving on the shaft, the lower section of the rings being suspended in oil. Ball bearings are often used on small machines with success.

CAPACITY

Generator manufacturers are usually glad to consider the particular requirements of the plater, and to offer suggestions concerning the capacity and type of machine required to meet his needs. It, of course,

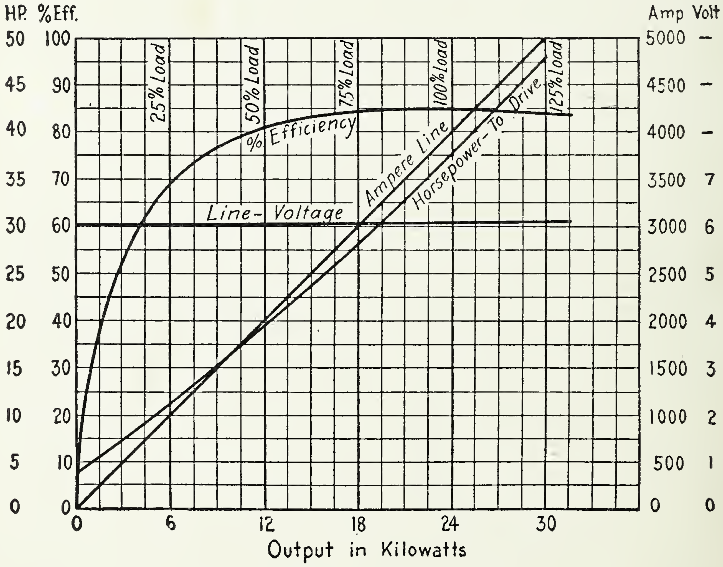


Fig. 33.—Performance Curve of 24K.W. Generator: 6 Volts, 4000 Amperes, 700 r.p.m.

(A. P. Munning & Co.)

must be remembered that there is no economy in purchasing a generator to care for only the present demand. An extra tank or two may be required in the near future to meet business expansion, and the increase in first cost for the larger machine capacity will then be fully repaid. A performance curve of a 24K.W. generator is given in Fig. 33 to show efficiency at various outputs.

LOCATION

As soon as the new generator is uncrated, a detailed examination should be made to discover what damage, if any, was caused during transit. Should all parts prove to be in perfect mechanical condition, place the generator upon the foundation previously prepared for it, bolting it down securely. If the machine is large, the foundation should be of concrete. Small generators may be supported on bridge work above the heads of the workmen. As has been previously stated, it is best to locate the generator and driving unit outside the plating and polishing rooms. Quite often a convenient space is found in a store room, office, or passageway adjoining the plating room. Because of the low potential and the cost of copper conductors, the generator should not be located more than fifteen or twenty feet from the tanks. All motors and generators installed in the plating room should have their windings protected from the acid fumes by treatment with an impregnating compound.

DRIVING UNIT

The generator may be belted to an engine, a power line shaft driving other machines, or an individual motor. Except in isolated shops, electric power is now available, and engine drive requiring additional attention is becoming unpopular. There are many occasions when the generator is the only machine requiring power. At such times the long line shafting and belting to other machines must be in motion, with resulting friction losses and waste of power. The modern electric motor requires little attention, is efficient, easily controlled, and may be maintained at slight cost. Obviously, then, individual motor drive should be chosen by the electroplater. A three phase alternating current motor, suitable for plating shop power, is illustrated in Fig. 34.

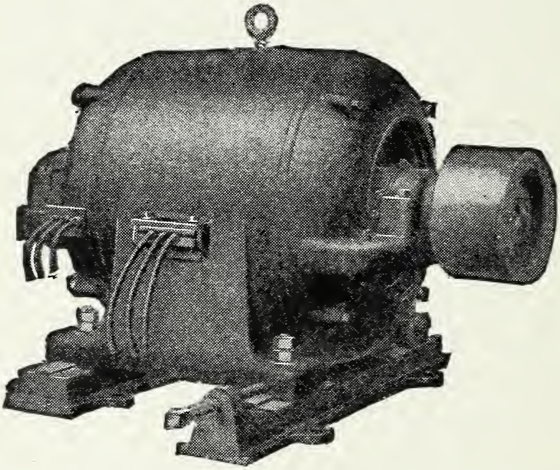


Fig. 34.—A Three Phase Alternating Current Motor.

(Wagner Electric Mfg. Co.)

MOTOR CAPACITY

The size and speed of the driving motor for any generator may be quickly calculated. It is remembered, from an earlier discussion, that the output of a direct current generator is measured in watts, the product of amperes and volts. Should this product in watts be divided by the conversion factor 746, the result is then expressed in horse-power. Suppose, for instance, it is desired to ascertain the motor capacity required to drive a generator whose name-plate indicates it is capable of a delivery of 1,500 amperes at 6 volts pressure. Thus the generator output is 9,000 watts, or, divided by 746, 12.06 h.p. But to choose the driving unit some account must be taken of the electrical and mechanical losses in the generator, counter shaft, and belts. A very safe estimate of the losses would be 25% of the generator capacity. Thus the driving unit must develop 15.07 h.p. A standard 15 h.p. motor would, accordingly, be specified.

MOTOR SPEED

Any motor speed can be selected, provided the pulleys on the counter shaft and generator are of such diameter as to drive the latter at the speed marked on the name-plate. It must be well understood that the generator speed cannot vary. Should speed indicator readings show any considerable variations, efficient plating work cannot be expected. If the driving unit is to be a direct current machine, it should be a shunt wound, as this type operates at a constant speed. Before starting up the motor, examination should be made to insure that the connections are such that the generator armature revolves in the correct direction: that is, the commutator turning away from the brushes.

GENERATOR VOLTAGE REGULATION

Voltage regulation is of the utmost importance in electro-deposition; an unchanging current flow of known value allows the plater to correctly determine the length of time required to produce a given deposit before the work is placed in the tanks. While the current flow is regulated at each tank by individual rheostats, it is nevertheless advisable to maintain a constant and normal line pressure. The terminal voltage of a generator depends upon the speed at which it is driven as well as the field excitation. Since the speed seldom varies, the true voltage must be held constant by increasing or decreasing the generator field excitation. This is easily accomplished by decreasing or increasing the resistance of the field circuit through the aid of a rheostat. The usual rheostat connections can be seen in the conventional diagrams, Figs. 20, 21, 22 and 24.

GENERATOR FIELD RHEOSTAT

A rheostat is a simple device so arranged that, by manipulating a handle, electrical contact is made with any division of a number of series-connected resistance units. These resistance units may be special alloy metal ribbons, or of wire wound on bobbins. A field rheostat is often subjected to heat from the resistance units, and the insulation is therefore usually of fireproof material.

THE AMMETER

Efficient work of any nature can only be accomplished when the workman is dealing with known quantities. For this reason the plater produces better results when he knows definitely the current passing through any tank. An ammeter is used for this purpose. There are several types available for use with direct current, but the so-called D'Arsonval galvanometer construction is most generally employed. A pivoted bobbin of wire is held between the poles of a permanent magnet. A light pointer is fastened to the bobbin in such manner that, when the latter is deflected by the magnet, the free end of the former swings over a divided scale. The scale divisions are calibrated to represent amperes, and the value of the current flowing in the bobbin winding is indicated by the deflection of the needle. An instrument of this nature is shown in Fig. 35.

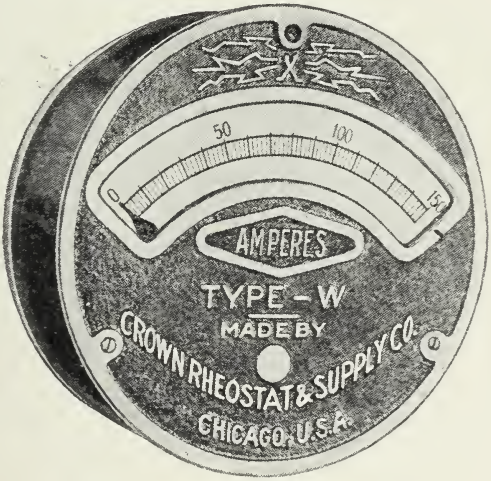


Fig. 35.—Ammeter

The windings of the ammeter coils cannot carry the heavy line current required for plating work. An ammeter shunt, of known resistance, is therefore used; this allows only a known small percentage of the line current to pass through the meter. The ammeter scale is, however, calibrated to show the total amperes flowing through the external shunt and meter coil combined. When the meter has once been calibrated, the same shunt must always be used; otherwise a new calibration must be made with another accurate instrument as a standard. Ammeter shunts and leads are furnished with the instrument, the latter being considered as a part of the meter circuit. External shunts are furnished only where large currents are to be measured; instruments for currents of small value are equipped with a shunt in the ammeter case. A typical ammeter shunt for use in the external circuit is shown in Fig. 36.

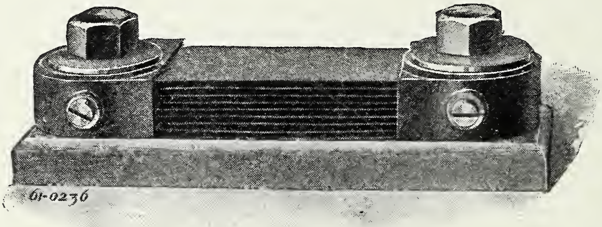


Fig. 36.—External Shunt for Ammeter

(Wagner Electric Mfg. Co.)

THE VOLTMETER

A voltmeter is an instrument employed to indicate the current pressure. In construction it is quite similar to the ammeter with the exception that the internal resistence is high instead of low. Hence the voltmeter may be connected directly across the line yet the current passing through it is practically negligible. A single voltmeter may be employed to indicate the potential difference of several tanks provided the required connections are made by the aid of switches. Such an arrangement is shown in Fig. 42, where one voltmeter is connected to serve six tanks.

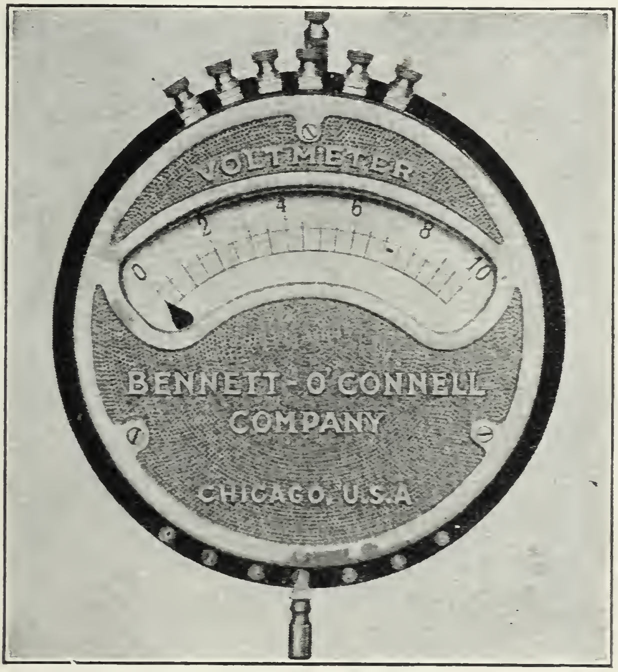


Fig. 37.—Voltmeter with Connections for Serving Six Tanks

THE AMPEREHOUR METER

In the past, the usual method of determining the weight of metal deposited on the articles undergoing electroplating was to note the lapse of time and the average current flow. The product of these two, or the ampere hours, might then be used to calculate the quantity of metal deposited. Competition and the rising cost of materials have made it necessary to eliminate waste in the deposition of metals. The use of the amperehour meter allows the plater to deposit only the predetermined amount of metal. The control of plating operations, with an instrument such as that illustrated in Fig. 38, is briefly explained by the manufacturer as follows:

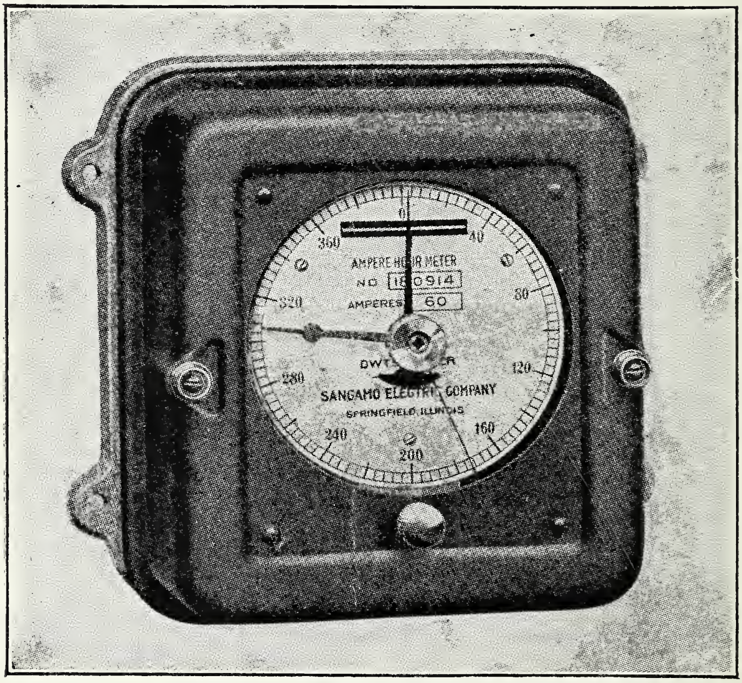


Fig. 38.—Amperehour Meter for Controlling Electroplating Operations

(Sangamo Electric Co.)

"The standard meter has a dial reading in any desired unit weights of the metal with which the meter is to be used; for example, dwt. of silver, grains of gold, pounds of copper, etc. The meter is equipped with a movable pointer, operated by a knob in the middle of the glass window over the dial, so that the pointer can be set at the amount of metal desired for any particular plating operation. For example, if twelve dozen spoons were to be silver-plated and required 100 dwt. of silver, the indicating pointer would be set at 100 on the dial, after which the large moving hand, operated by the mechanism of the meter, would be set at the zero point. As the current passes through the meter, the large hand moves in a clockwise direction around the dial until it reaches the pointer, in this case set at 100 dwt., when contact is made against a pin in the adjustable pointer, thus operating through auxiliary leads to an electric light or bell, as a signal." The external connections for the amperehour meter are shown in Fig. 39 and can be easily understood.

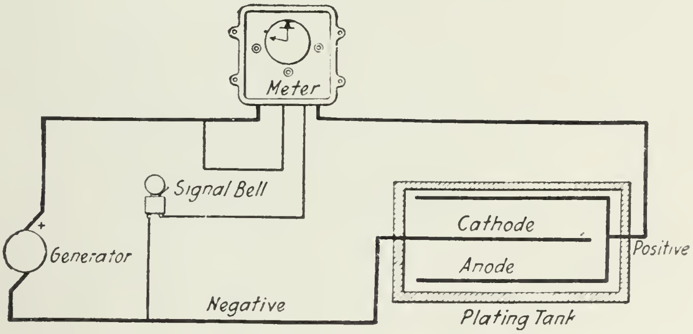


Fig. 39.—Connections for Amperehour Meter

TANK RHEOSTAT

As was explained in Chapter II, the quantity of current flowing in any one of a number of parallel circuits is dependent upon the resistance of that branch. This condition is duplicated in the case of a number of multiple-connected plating tanks pre-

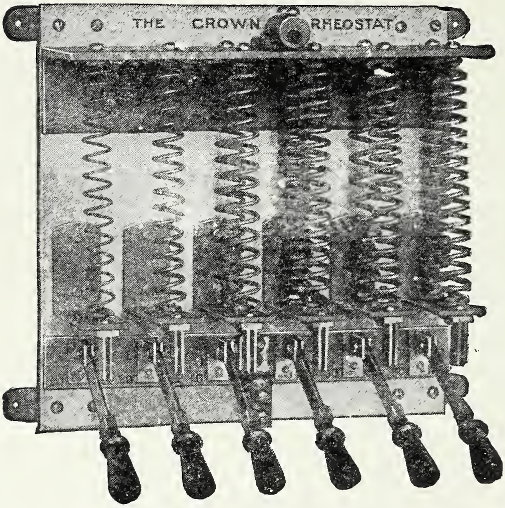


Fig. 40.—Tank Rheostat: Knife Switch Type

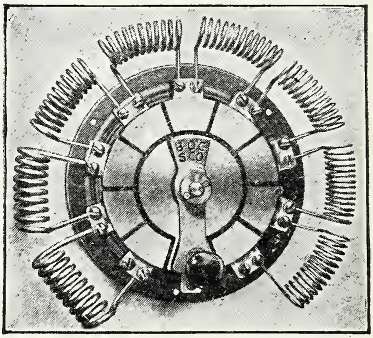


Fig. 41.—Twelve Spring Dial Type Rheostat

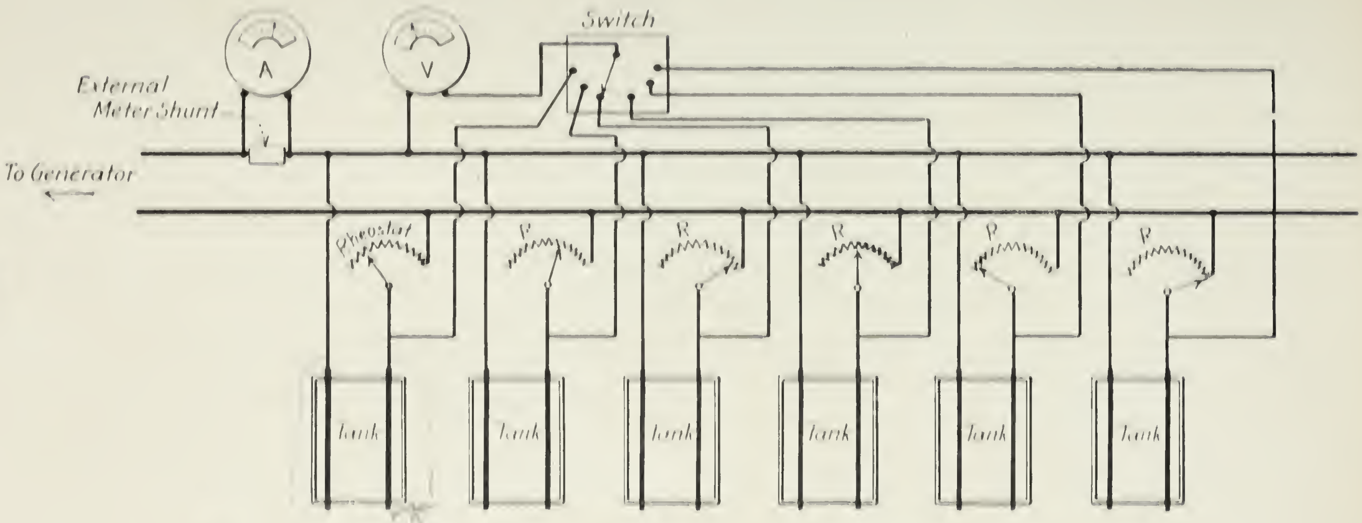


Fig. 42.—A Two Wire System: Ammeter and Voltmeter Connections

senting various resistances to the flow of current. It is obviously impossible to place equal quantities of work in each tank to balance the resistances. A rheostat may be furnished, however, for each tank which, being connected in series with it, serves to regulate the voltage and thereby the current. Figs. 40 and 41 indicate types of tank rheostats so arranged that the e.m.f. can be regulated to a fraction of a volt.

TWO WIRE SYSTEM

The most simple method of forming connections for the plating tank is indicated in Fig 42. This might be termed a two-wire system. Only two supply wires, or bus bars, positive and negative, are provided.

THREE WIRE SYSTEM

In recent years the three wire, or multiple voltage, system of distribution has come into favor. The standard plating dynamo is usually wound to produce a current pressure of six volts. There are many classes of work, however, which require voltages somewhat above six. In response to the demand for greater flexibility, specially designed, two commutator, double voltage generators are available. When wired, as shown in the diagram, Fig. 43, with neutral, positive, and negative supply lines, any voltages up to 12 are obtainable. For the usual run of work the 6-volt current is employed; when higher voltages are desired, the switch is thrown to the 12-volt supply line. Tank rheostats regulate the intermediate voltages. This system is particularly useful where high voltage barrel plating is employed part of the time.

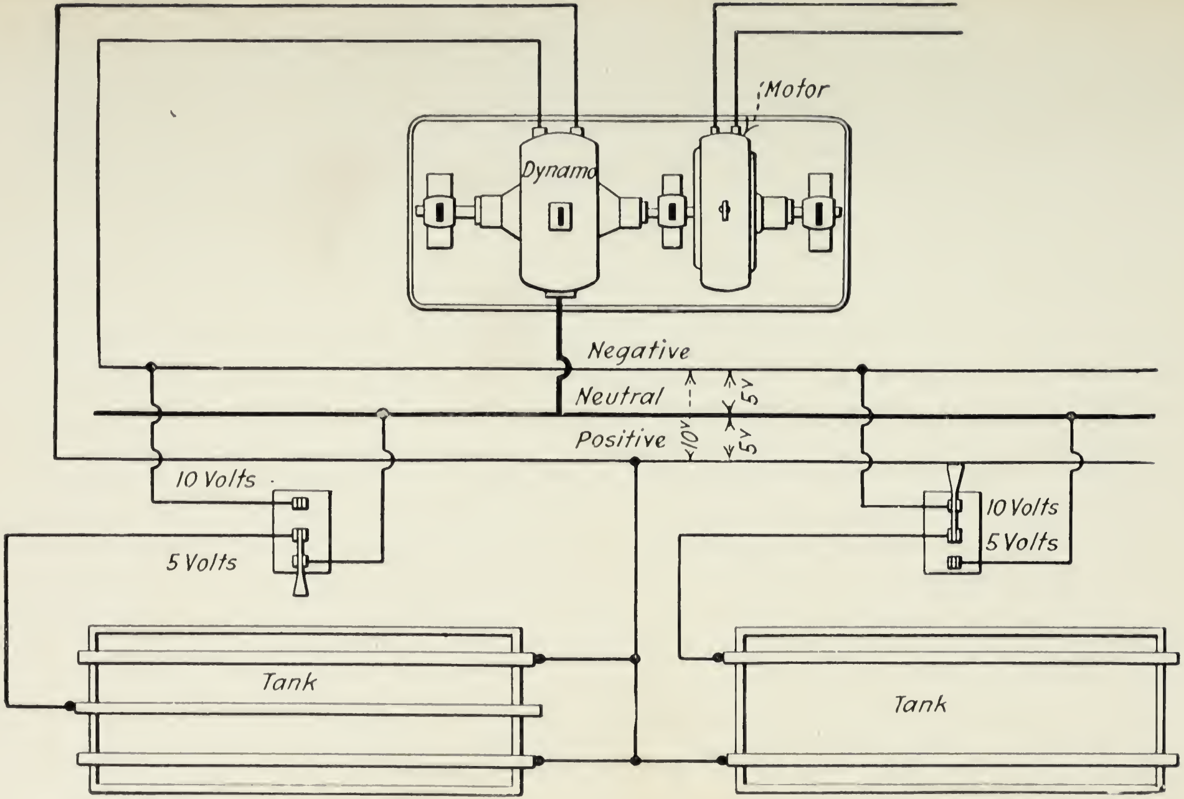


Fig. 43.—Method of Wiring for Multiple Voltage System

CHAPTER V

ELECTROPLATING TANK EQUIPMENT

Tank Capacity—Three-Types of Plating Tanks—Still Tanks—Earthenware Tanks—Steel Tanks—Wooden Tanks—Tank Construction—Advantage of Warm Plating Baths—Steam Coil Heater—Insulating Joint—Regulating Valve—Solution Agitation—Agitation with Air—Tank Rods—Plumbing—Rotating Plating Barrels—Automatic Plating Machinery—Automatic Moving Tank—Principal Advantages—General Design—Other Types—Tanks for Preparatory Processes—Pickling Tanks—Bright Dipping Tanks—Special Ventilating Hoods—Lye and Potash Tanks—Hot Water Tanks—Scouring Tanks.

TANK CAPACITY

Plating-room efficiency is, in a large measure, dependent upon the size, type, and location of the solution tanks. A study of the type of work required and the daily production necessary to maintain the desired schedule, will provide a basis for an estimate of the necessary tank capacity. It is better to have a portion of an extra tank idle than to crowd a few with work. A safety margin providing for equipment breakdowns is well worth the added investment.

THREE TYPES OF PLATING TANKS

There are three main types of plating tanks. The most important and generally used type is the still tank which is merely a steel, earthenware, or wood vat in which neither the solution, anodes, or cathodes move during the plating process. Small articles in quantities may be quickly plated in the second type, a rotating barrel. There are several kinds of these mechanical plating tanks, but in all cases the articles tumble over each other as the deposition process continues. The third general type is the automatic plating machine. Usually, with this device, the work is cleaned, plated, washed and dried without any assistance from the operator. A more detailed description of these general types will be considered in the following paragraphs.

STILL TANKS

Vats or tanks for electrolytic or other solutions, are constructed of earthenware, metal, or wood. In capacity they usually range from four gallons upward.

EARTHENWARE TANKS

Because earthenware tanks are somewhat fragile, they are not often used where another type can be substituted. They are, however, especially useful for holding acid and cyanide solutions. Hydrofluoric acid, since it attacks clay compositions, cannot be used in an earthenware tank. Stoneware vats may be used with all solutions except hot sulphuric acid and hydrofluoric acid. If proper care is exercised to see that they do not crack, these tanks will last indefinitely, there being no appreciable disintegration.

STEEL TANKS

Steel tanks are available in many forms. The welded steel container presents the best appearance, since there are no seams or rivets visible. Usually the seams are closed by oxy-acetylene welding, the material thus added increasing the strength of the metal bond. Riveted and caulked joints also give good service but the possibility of leakage is always present. Boiler steel, approximately 3/16 inch in thickness, is used in the construction of the average steel vat. Unlined, they make excellent containers for hot water, lye, potash, and cyanide solutions.

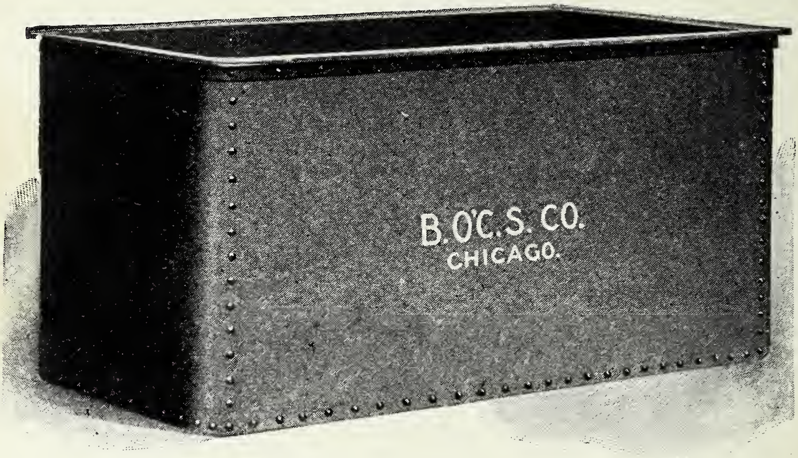


Fig. 44.—Electric Welded or Steel Riveted Tank

(Bennett O'Connell Co.)

When the inside surface is prepared with an acid-proof paint or asphaltum, they may be utilized for plating tanks. Enamel-lined iron containers are especially recommended for cyanide solutions, gold and silver electrolytes, lacquers, and other non-acid solutions. The enamel lining, however, chips easily if struck a sharp blow. An electrically welded tank with riveted top is shown in Fig. 44 and a chemically enamelled iron tank is depicted in Fig. 45.

WOODEN TANKS

Most popular of all types is the wooden tank. Inexpensive and easily constructed, it always finds favor in the plating room. Such containers may be purchased, made to dimensions desired by the electroplater. When an asphaltum or other lining is specified, it is usually applied after the delivery of the tank, since the continuous jarring during transit cracks a lining applied at the factory. Lead-lined tanks are more serviceable; but the added expense often causes the prospective purchaser to choose the cheaper painted coating.

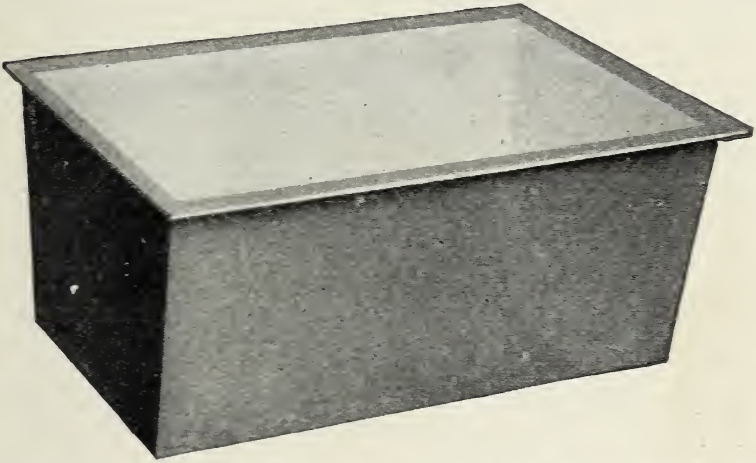


Fig. 45.—Chemically Enameled Iron Tank for Gold, Silver, Cyanide Solutions, and Lacquers

(Crown Rheostat & Supply Co.)

The wooden tank is by no means difficult to construct, although a certain knowledge of wood working is, of course, essential. There is a satisfaction in building one's own equipment, aside from the material saving in the cost.

TANK CONSTRUCTION

Although the tank may be built in any desired dimensions, in general it should be about twice as long and nearly as high as it is wide. For instance, 7 feet long, 3½ feet wide and 3 feet high gives a well-proportioned tank for fairly large work.

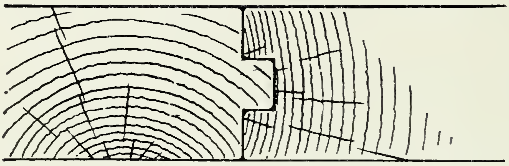


Fig. 46.—To Obtain a Tight Fit the Edges of the Boards Should Be Grooved

If possible, kiln-dried cypress lumber should be secured, 2 inches thick and 10 to 12 inches wide. After deciding what are to be the dimensions, the

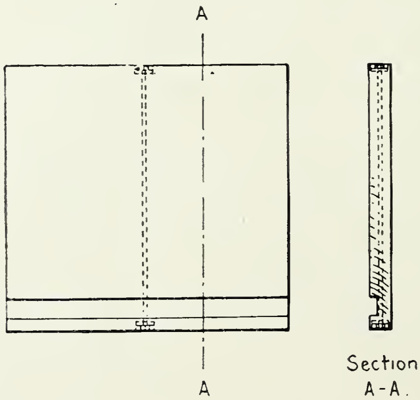


Fig. 47.—End Boards Assembled, Showing Grooving for Bottom Pieces

two end-board assemblies should be constructed, the edges of the boards being grooved, as shown in Fig. 46, so that they fit together tightly. Temporary cleats may be nailed across the boards to hold them together until the final set up. Two inches from the bottom edge of each of the end-board assemblies, a groove, ¾ inch deep and as wide as the thickness of the lumber to be used for the tank bottom, is cut,

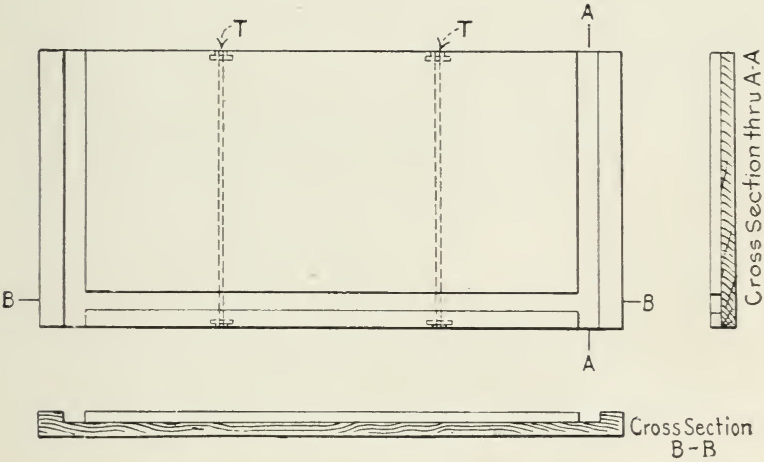


Fig. 48.—Side Boards Assembled and Grooved to Match Bottom and End Pieces

as indicated in Fig. 47. In cutting all the grooves necessary in constructing this tank, the greatest care must be exercised to produce a neat, tight fit. A loose joint necessarily causes leaks.

In a similar manner two side-board assemblies are made ready. By referring to Fig. 48, it is seen that three grooves are cut, one for each end piece, and one for the bottom boards. Each groove is cut 2 inches from the end or edge of the boards, as the case may be.

As soon as the bottom boards are cut to correct length and matched together, the general assembly is made. Thoroughly treat all grooves with the acid-proof paint prior to this final operation. If the several pieces match perfectly, arrange to hold them securely in place with several steel tie rods.

For a tank of average size, four tie bolts at each end and seven along the bottom are sufficient. If the tank is to be lead-lined, the number may be decreased. The bolts are made of 3/8 inch diameter steel rods cut to the correct length and threaded at each end. For the bottom bolts, iron washers may be placed next to the wood, but for the end rods iron plates are provided, one inch wide, 1/4 inch thick, and of sufficient length to span all of the side boards. Holes are drilled in these plates through which the tie rods or bolts may pass. Tighten all the nuts to the greatest possible extent without stripping the threads. This will draw all joints together. If it is seen that the

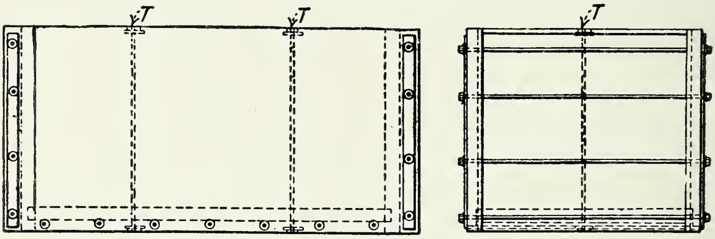


Fig. 49.—Front and Side Views of Wooden Plating Tank. Note That the Bottom and Sides are Matched Into Each Other

several boards, when assembled for the side and end pieces, do not match perfectly, or have a tendency to separate, further precautions must be taken. Bore ¼-inch holes through the several boards at right angles to their length and parallel to their width. Tie bolts passed through the boards can then be used to draw them together. The letter T denotes these special bolts in the illustrations in Fig. 49, which shows front and side views of a conventional wooden plating tank.

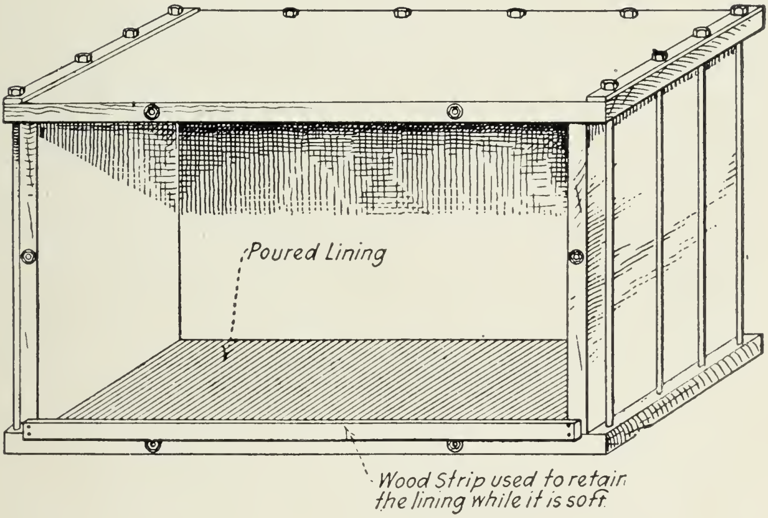


Fig. 50.—Method of Pouring Tank Lining

Lining the tank with lead sheeting is difficult, and an inexperienced workman will not find it easy work to fuse together the seams. An asphaltum, or other prepared tank lining, can be applied with much greater success and at less expense. First paint the inside tank surface with a thin coating of the prepared lining. As soon as it is dry, spread over this painted portion a coarse grade of cheese cloth, tacking it down at several points to insure a smooth surface. Several heavy coats of the lining material are then painted over the cloth, the latter acting as a reinforcement to prevent cracking or flaking of the prepared surface after it is dry. Time should, of course, be given between paint applications to allow the previous coating to harden.

Another method of lining the tank which is quite satisfactory might also be suggested. Lay the tank on its side. Tack a strip of wood along the outer edge of the downward side, as is indicated in Fig. 50. Using a carpenter's level, adjust the tank with great care so that the downward side is perfectly level. When all is thus prepared, pour in the lining material until it settles over the surface to the desired depth. As soon as the poured surface is hard, turn the tank to the opposite side and repeat the process. When all four sides are treated, turn the tank right side up and pour in a slightly heavier layer for the bottom. Prepared tank lining material is often inflammable, and it is therefore best to heat or mix it in the open air or where there is no fire hazard.

ADVANTAGE OF WARM PLATING BATHS

One of the many puzzling phenomena is that the resistance to the flow of current through a metallic conductor increases with the rise in temperature of that conductor, while just the opposite is true in the action of plating solutions. An increase in the temperature of the electrolyte results in a decrease in electrical resistance. It is therefore seen that it is to the advantage of the plater to use warm solutions. During the summer months artificial heat is not required, but on cold winter days the temperature of the plating bath must be maintained constant and above 50° F., if satisfactory work is to be expected.

STEAM COIL HEATER

A steam coil laid on the bottom of the tank or, as indicated in Fig. 51, at one end, is sufficient to heat the solution. The last mentioned U-shaped coil is perhaps the most simple to construct. A one-inch lead pipe is cut to the correct length and formed to fit the tank. Each end is connected with an insulating steam joint or coupling.

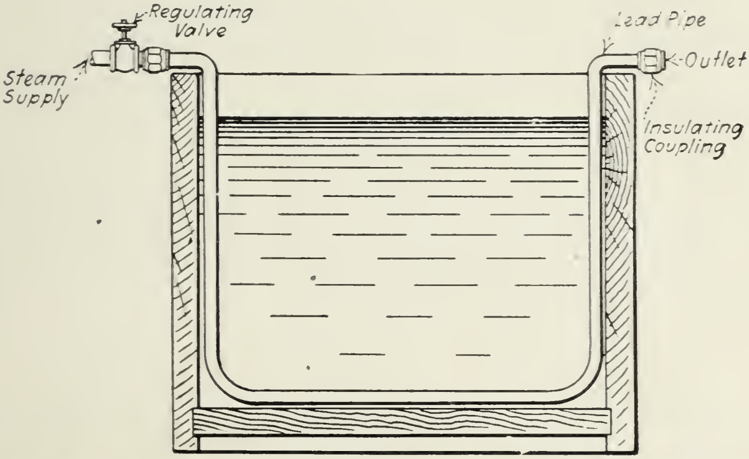


Fig. 51.—Steam, Passing Through a Lead Pipe Submerged in the Electrolyte, Supplies the Required Heat

INSULATING JOINT

Insulating joints are required to prevent the leakage of electric current from the tank circuit through the piping system. A cross section of such a joint is shown in Fig. 52. They can be purchased in sizes ranging from ¼ to 1½ inch with standard threads.

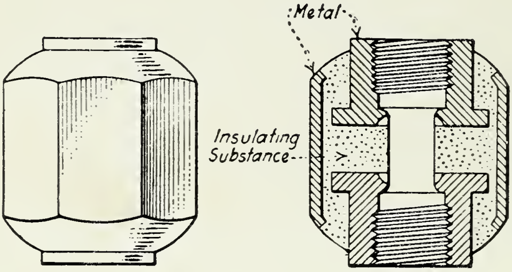


Fig. 52.—Insulating Joint or Coupling for Steam or Air Pipes. Used to Prevent Leakage of Electric Current Through Piping System

REGULATING VALVE

For convenience in regulating the temperature, a steam pressure adjusting valve should be inserted on the inlet side of the steam coil.

SOLUTION AGITATION

During the process of plating, tiny gas bubbles form on the anodes. The effect of these bubbles is to decrease the active area of the positive plate, thereby increasing the resistance to the flow of current to the electrolyte. Unless the bubbles are removed by some exterior means, a more concentrated plating solution must be used to counteract the detrimental effect of the small anode area. Solution agitation is, therefore, often employed, with the result that a fine, close-grained deposit is obtained with a low current density.

AGITATION WITH AIR

While mechanical agitation is, perhaps, the most effective method available for tank work, the special machinery is not only expensive but it often utilizes valuable space. On the other hand, compressed air agitation is simple and the system may be constructed and installed in a few hours time. Compressed air is available in most shops of average size, and certainly if the plating room is a department of an industrial plant. It is only necessary to drill a large number of small holes in a length of one-inch lead pipe, sealed at one end. This pipe is then laid along the center line of the bottom of the tank, as shown in Fig. 53, the free end passing up over the tank edge where it is connected, through an insulating joint and

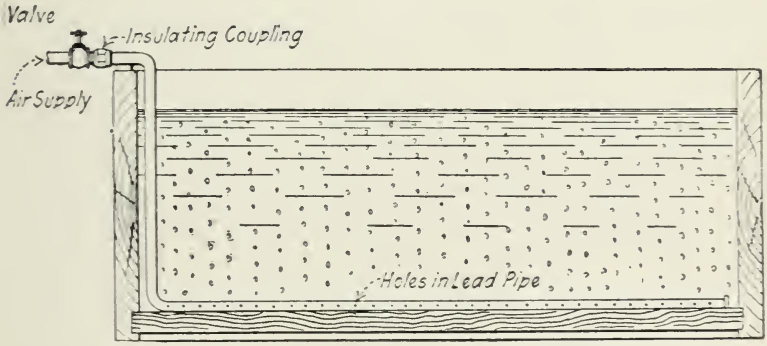


Fig. 53.—Cross Section of Plating Tank, Showing Agitation of Solution by Bubbles of Compressed Air Released From Perforations in Lead Pipe Laying on Bottom of Tank

regulating valve, to the air supply. The tiny bubbles of escaped air pass upward through the solution, effectively agitating it.

TANK RODS

While installing the heating coils and agitation system, it is well to keep in mind the location of the bus bars or tank rods for the anodes and the plating work. When the tank is used almost exclusively for plating large articles, one cathode rod is placed along the center line of the tank with an anode rod on either side. The cathode should always be provided with an anode on each side to equalize the plating action. Thus, if two cathode bars are placed to a tank, there should be three anode rods, and so on. If the plating tanks are constructed of metal or of wood lined with lead, it is necessary to provide an insulator, such as a block of wood, to prevent the rods

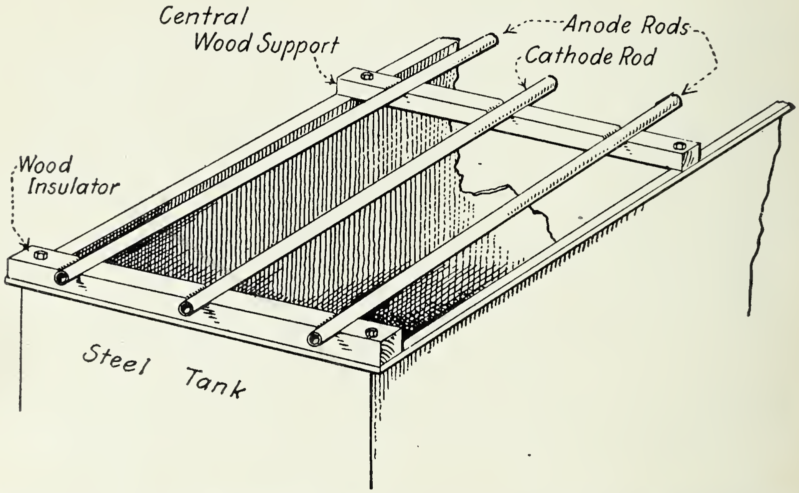


Fig. 54.—Wood Insulators for Anode and Cathode Rods Used With Metal Tank

coming in contact with the metal. Such a provision is shown in Fig. 54. The anode and cathode rods must not only be of sufficient size to carry the heavy plating current, but to support as well the weight hung upon them. A copper rod can safely carry the current but not the weight; a thin brass tube may carry the weight, but its capacity as an electrical conductor may be below the particular requirements. As a general rule, a brass or copper tube with a wall of liberal thickness answers most requirements. The plater should, of course, consult a table of values and sizes before making the installation.

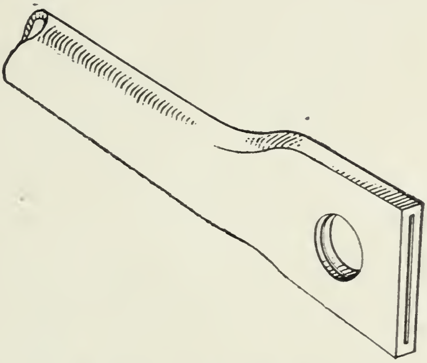


Fig. 55.—End of Anode or Cathode Tube Flattened and Drilled to Make Electrical Connection by Bolting to Supply Bus Bar

Since low voltage is necessary for plating work, the greatest care must always be exercised to see that every electrical connection is perfect. There are few such connections which can be soldered, and bolting is, therefore, relied upon to make a tight contact. To assist in making these connections, each anode and cathode rod or tube is flattened at the connector end, and drilled to match the bolt hole in the bus bar.

Note Fig. 55. The electrical connections and distributing systems are described in another chapter.

PLUMBING

As soon as the various plating tanks are placed in a permanent position, the plumbing should be so arranged that each container is provided with a faucet directly over it, thus allowing the plater to fill the tank with water without effort or inconvenience.

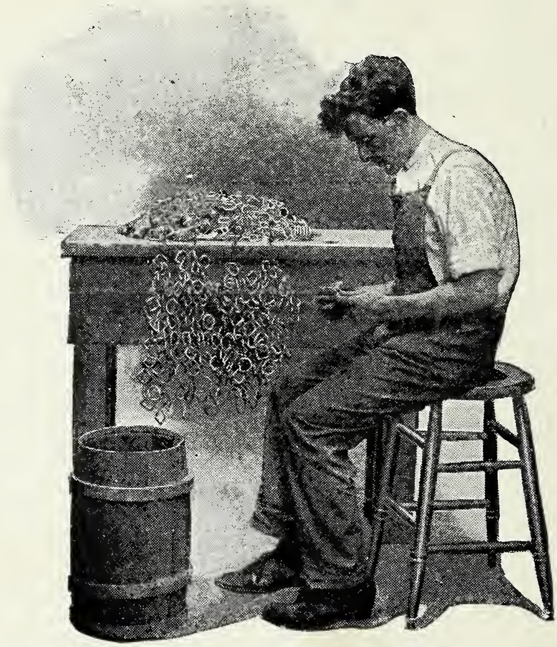


Fig. 56.—Stringing the Work for the Still Tank. This Method is Slow and Tedious

(Hanson & Van Winkle Co.)

ROTATING PLATING BARRELS

As has already been intimated, the quickest and cheapest method of plating large quantities of small articles is the mechanical rotating barrel. In appearance it is not unlike the familiar tumbler used in cleaning metal castings or tarnished punchings. A metal plate, fastened to the inside bottom of the barrel, is connected, through a collector ring on the outside bottom, to a brush contact with the negative bus bar. The anode is suspended from a steel arm and is stationary, while the barrel rotates. Articles placed in the barrel make electrical contact with the negative base plate and, as they tumble over each

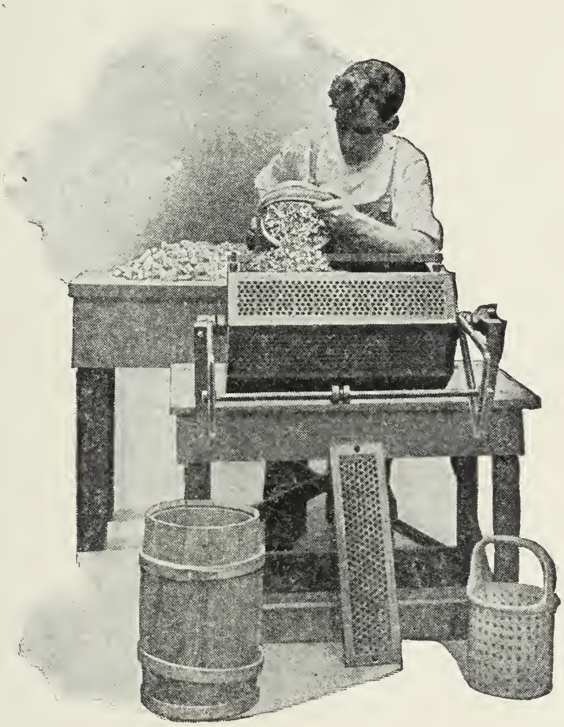


Fig. 57.—Modern Methods Permit Quantity Production. Loading a Plating Barrel With Small Work.
(Hanson & Van Winkle Co.)

other, the plating process continues. This tumbling action insures a uniform deposit of metal upon each article. One of the great advantages of this type of plating tank is that any piece of work can be conveniently removed for inspection without stopping the machine. The entire batch of work is removed

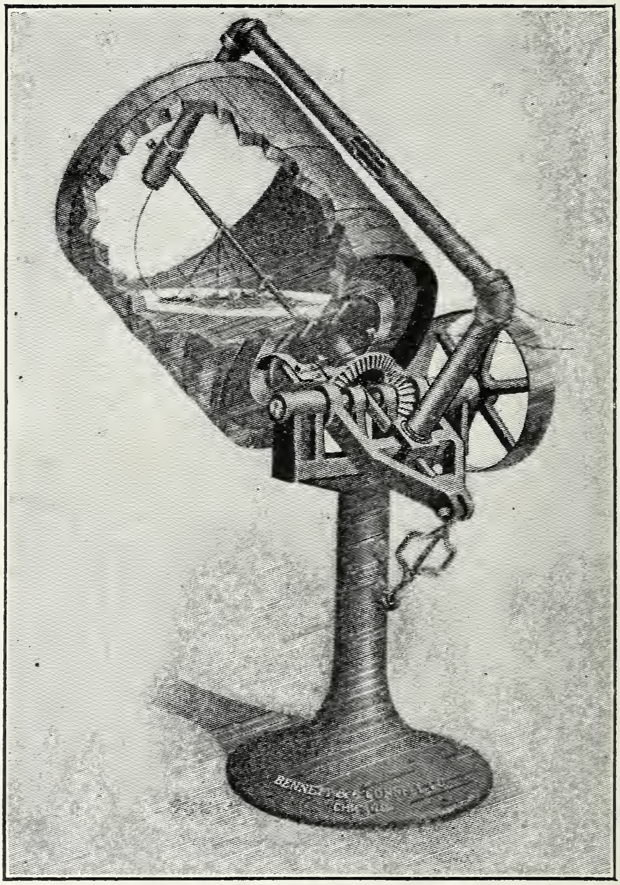


Fig. 58.—Tilting Type Rotary Plating Barrel Showing Position of Anode

(Bennett O'Connell Co.)

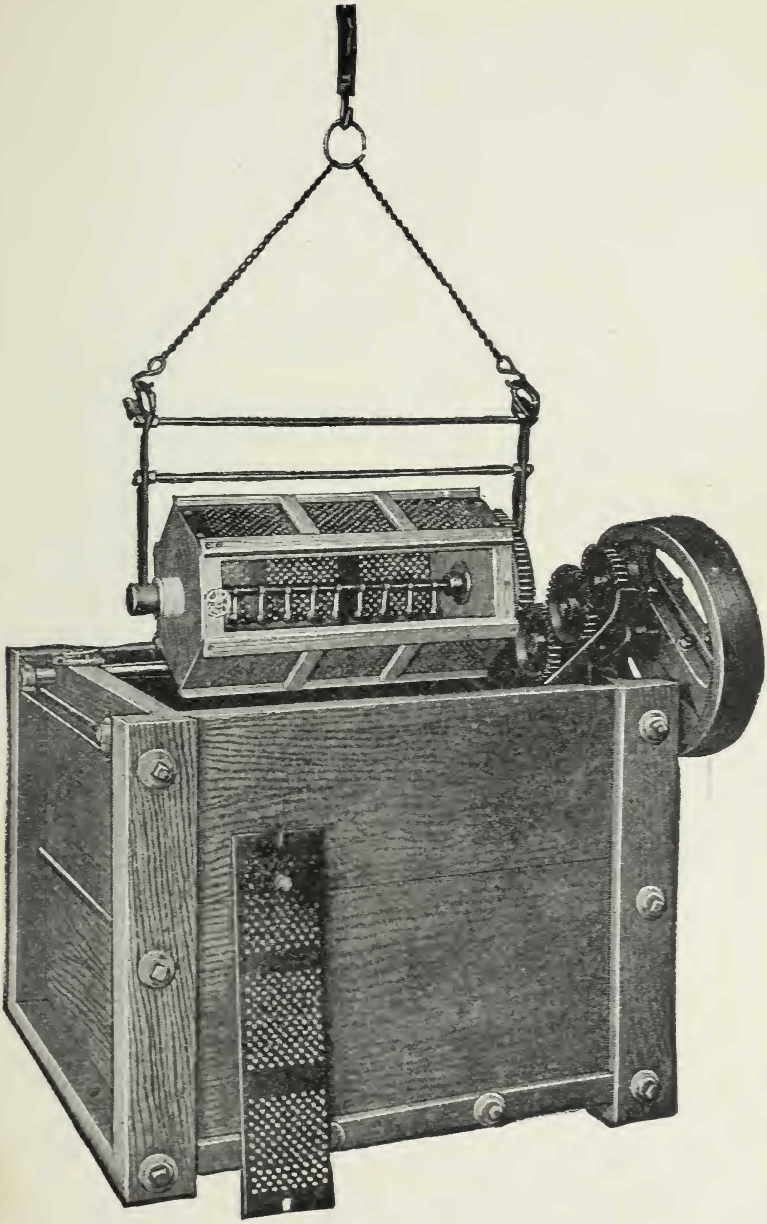


Fig. 59.—Rotating Plating Tank: Container Raised for Refilling

(General Platers' Supply Co.)

by scooping or by dumping. Fig. 58 illustrates this modern plating barrel.

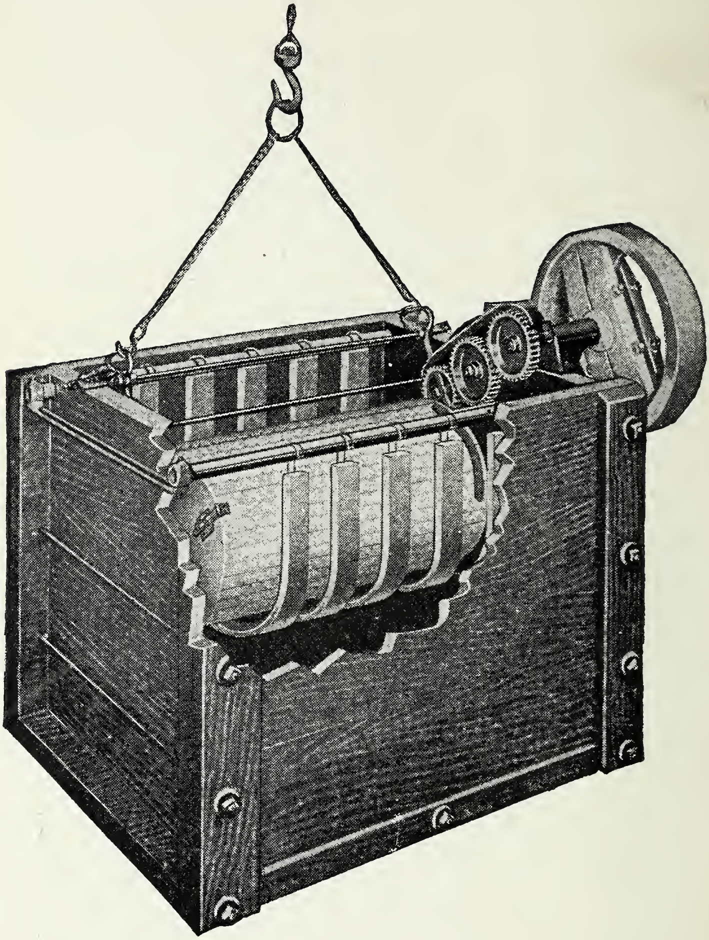


Fig. 60.—View of Rotating Plating Tank Showing Position of Anodes and Container During the Deposition Process

(General Platers' Supply Co.)

Another type of rotary plating tank is so designed that the articles are "tumbled" in a horizontal perforated cylinder revolving beneath the surface of the electrolyte. To load or unload the cylinder, it is necessary to hoist it above the surface of the solution, when the cover plate can be removed. Better results can usually be obtained if curved anodes are used, thus providing an anode surface below the cylinder as well as at the sides. The cathode connection to the article is formed by a contact with metal pendants suspended from the metal axis of the cylinder. This axis is, of course, connected to the negative bus bar. The cylinder is constructed of a non-metallic substance, such as bakelite, and is thus not affected by the plating currents. The barrel type machine is also designed as shown in Fig. 61.

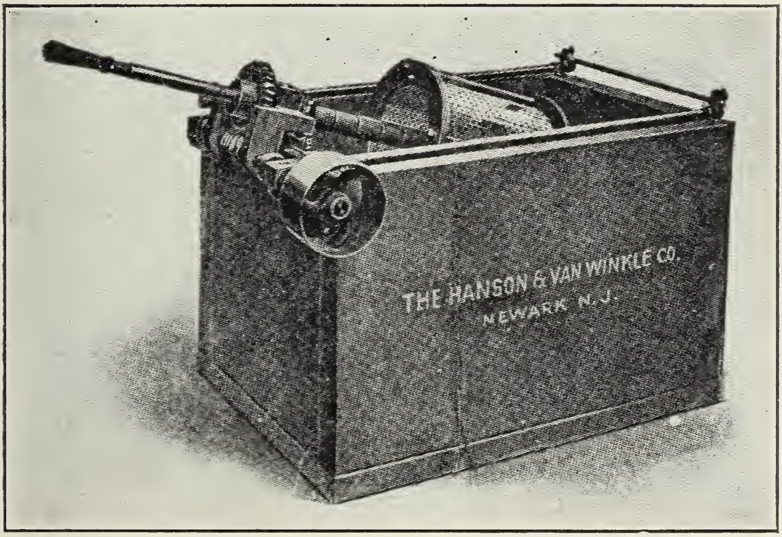


Fig. 61.—Oblique Plating Barrel. This Type Is Quite as Efficient as the Horizontal Machine and May Be Employed for Smaller Quantities of Work.

(Hanson & Van Winkle Co.)

In operating any of these barrel-type plating machines it must be remembered that they are quite similar to the still tank as far as the deposition process is concerned. The speed of rotation must be slow, fifteen to twenty r.p.m. being sufficient. No good and much harm will result if the barrel is operated at a higher speed.

AUTOMATIC PLATING MACHINERY

The trend of the industrial world is toward the use of automatic machinery. While electroplating requires, perhaps, more of the human element than most forms of industry, progressive manufacturers have placed upon the market machinery designed to increase production with a corresponding decrease in labor and time. Various types of plating machines are illustrated; a typical automatic installation is outlined in Fig. 62.

Perhaps the most simple type operates as a conveyer, the article passing through the solution in a definite time at a rate of speed determined by the length of time required to deposit the metal coating. So important is the use of the automatic-moving tank in modern electroplating, that a detailed description is necessary. Through the courtesy of the Crown Rheostat and Supply Company, it is possible to give the following excellent comparison between still and automatic-moving tank methods.

AUTOMATIC MOVING TANK

"In considering the electrical deposition of metal in the old style plating tank, it is found necessary to use a comparatively low ampere per square foot of cathode surface and a low voltage. This is due to the fact that in the act of electroplating, hydrogen gas bubbles form on the cathode and if a higher current were used, the work would burn or become rough. This necessity for a low current therefore causes a much slower deposit to take place than could be obtained if the hydrogen bubbles could be eliminated in some way.

By the use of a moving apparatus to convey the articles through the tank as they are being plated, this and many other defects can not only be removed, but new and favorable conditions created.

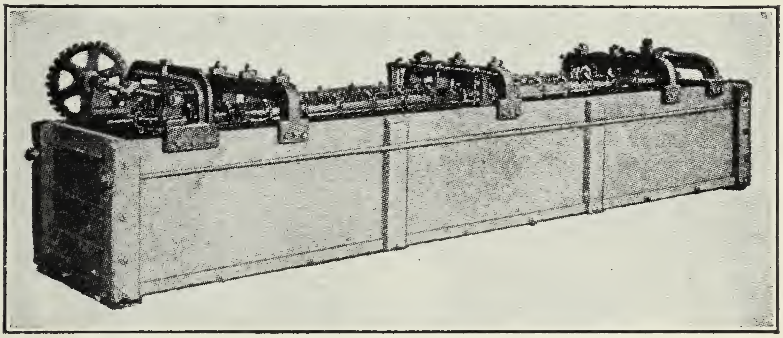


Fig. 62.—General View of Automatic Moving Plating Tank

The act of moving the cathode through the solution, frees the hydrogen bubbles from the material and a higher current can therefore be used without burning the surface. The result is a much quicker and denser deposit.

Another condition encountered in still tank practice, is that it requires a good deal of judgment and care on the part of the plater, in order to leave all of the material in the tank the same length of time, and to secure uniform work, even under favorable conditions.

After the proper length of time is determined for plating, it will require no careful watching or judgment as to how long each piece is left in the moving tank as the pieces must remain in the same length of time. They are placed on racks which are hung on the conveyor chain, and when they have made the circuit of the tank and come back to the starting-point, they are removed by the operator. This results in a deposit of uniform thickness on all the articles.

In the still tank, it is seldom found that all the conditions in the tank are perfect. Some of the anodes, for instance, will secure a better electrical contact owing to the condition of the surface of the anode hook or to dirty contacts on some of them, or to corrosion or dirt on the anode-contact bar. Other anodes become foul and must be frequently cleaned or they will wear away unevenly. Under these conditions, no matter how skillful the plater is, it is almost impossible to secure uniform, even work, because material placed near the active anodes will plate faster than that which is placed near sluggish or inactive anodes.

On the other hand, with the automatic-moving apparatus tank, the anodes cannot get foul owing to the agitation of the solution, and if some of them dissolve or wear away, more than others, due to poor contacts, it will not affect the uniformity of the work because each article will pass all of the anodes, both good and bad, and each piece will have the same exposure as all the other pieces.

Another point with the still tank which is seldom realized, is the fact that the solution in immediate contact with the cathode (article being plated) becomes impoverished of metal after a very few minutes, and the molecules of metal having to be carried from an increasing distance as the plating progresses, the amount of deposit taking place is diminishing on an increasing scale. On articles having recesses, this is particularly noticeable as the solution in the recesses soon becomes impoverished, and after that the molecules of metal are only deposited on the high spots or places nearest their line of travel.

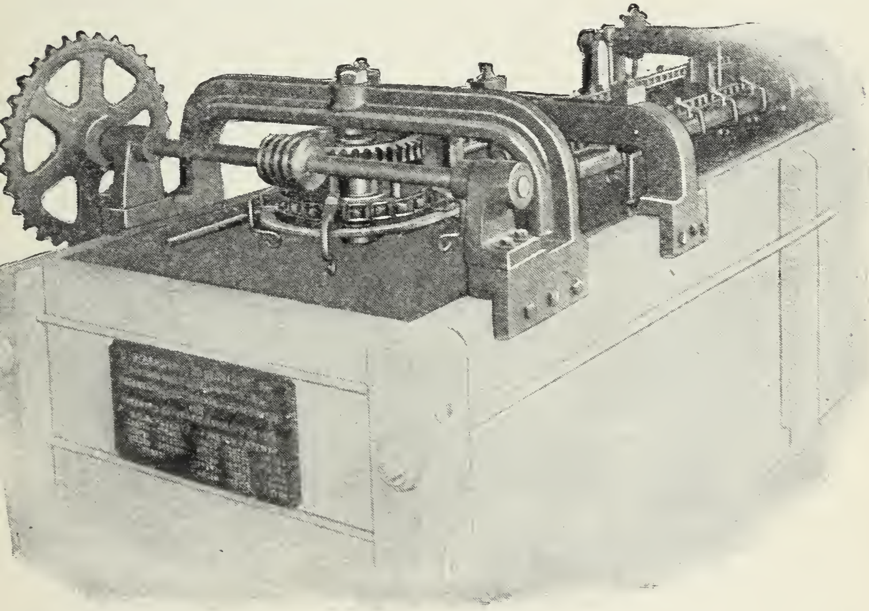


Fig. 63.—View of Automatic Plating Tank, Showing Driving Worm Gear and Copper Hooks

With the moving apparatus tank, however, rich solution high in metal content, is always in contact with the cathode, because as fast as the metal is taken from the solution, the articles are passing on to new solution. This condition aids materially in quickening the deposit, and its beneficial results are particularly noticeable in deep recesses which are impossible to plate or electrogalvanize in a still tank. The action set up by the material passing through the tank is also sufficient to stir or agitate the fluid enough, for the dense solution is always found near the anodes, to become mixed with the poorer solution impoverished by the cathode and the latter solution to be moved toward the anode. This in turn aids and quickens the dissolving of the anodes.

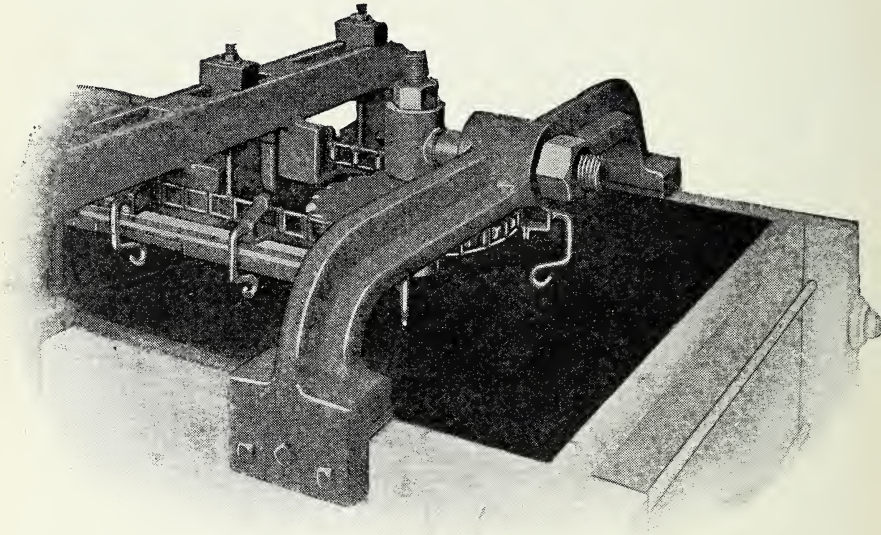


Fig. 64.—View of Automatic Plating Tank Showing Arrangement for Taking up Slack in Chain

The moving apparatus tank goes beyond the mere correcting of certain defects of the still tank and sets up new and attractive conditions. For instance, the racks above referred to are hung on copper hooks which are fastened to the link-belt conveyor chain. These hooks slide on a flat copper conductor bar, and this sliding operation is just enough to keep the connections bright and clean.

The automatic moving tank, for two reasons, requires less floor space than the still tank. In the first place, these tanks can be set close together. They are loaded from the end and do not require the wide passageway between them that still tanks do. In the second place, they plate the work quicker than still tanks and fewer of them are required. If your plating department is crowded and congested the automatic-moving tank will solve your problem.

PRINCIPAL ADVANTAGES

It can readily be seen then, that with a moving apparatus we can use a higher current, resulting in a quicker deposit; employ unskilled labor owing to fixed length of time of articles in the plating bath; secure uniform deposit on all work because of equal exposure to all anodes; quicken the deposit and plate in recesses because articles are always in contact with rich solution; save each of your platers from walking needlessly a long distance each day; prevent a big loss of current which you are now losing by being able to use only about one-half of the voltage generated; and aid the above-created efficiency by automatically keeping the cathode conductor bar clean and bright.

GENERAL DESIGN

The apparatus is so laid out that it can be installed on any tank which is 2 feet 6 inches wide. There are two main yokes and two or more conductor supporters which are bolted to the top of the tank. The moving apparatus, anode conductor bars, cathode conductors, etc., are supported by these yokes and supports. There is no part of the apparatus in the solution except the agitator.''

OTHER TYPES

Automatic machines are also in use for producing plated surfaces on hoop-iron, wire, strip copper and brass, and wire mesh. These machines are distinctly automatic in that they provide for pickling and cleaning operations prior to that of plating. Although the work is usually dried and wound on reels at the completion of the process, a lacquering operation may be added, when it is necessary to provide a drying oven. Machinery for electroplating metal wire and strips is shown in Fig. 65. The automatic plating apparatus for handling wire mesh is shown in Fig. 66.

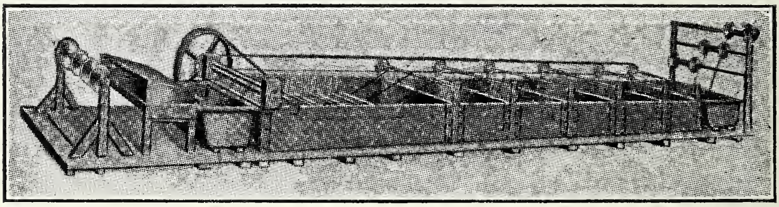


Fig. 65.—Machinery for Electroplating Wire, Hoop Iron, and Similar Work by the Continuous Process Method.

(Hanson & Van Winkle Co.)

A mechanical plating tank for chains, automobile wheel irms, etc., is shown in Fig. 67.

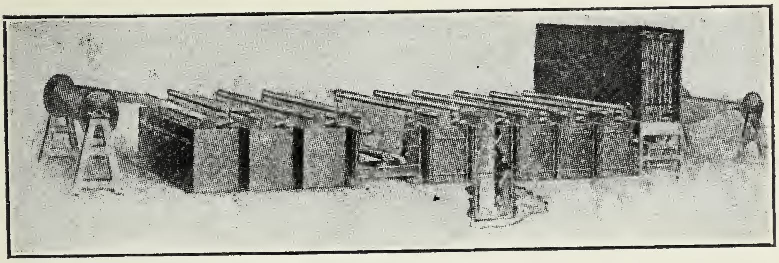


Fig. 66.—Special Automatic Machinery for the Electro-Deposition of Protective Metals on Wire Mesh. Note the Arrangement for the Preparatory Processes, Plating, Washing, Drying, and Lacquering.

(Hanson & Van Winkle Co.)

Other machines are on the market which are designed for special work, such as plating chains, bar-

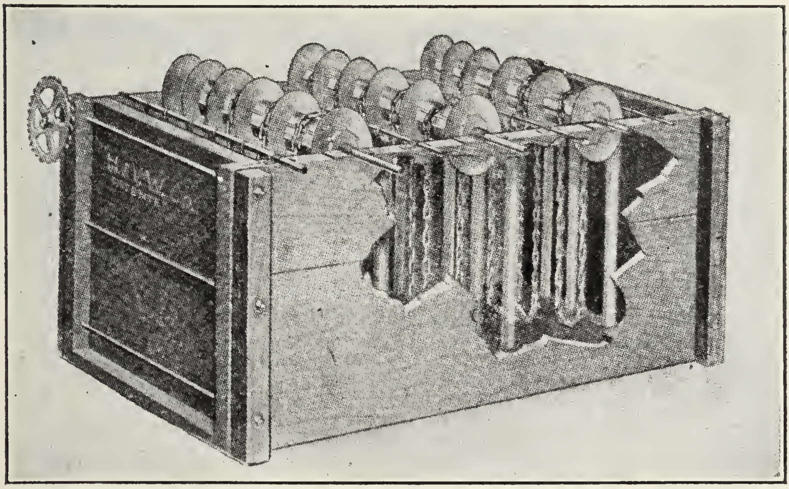


Fig. 67.—Mechanical Plating Tank for Chains, Automobile Tire Rims, and Work of a Similar Character.

(Hanson & Van Winkle Co.)

rel hoops, automobile tire rims, metal tubing and the like. Automatic plating machinery will undoubtedly be further developed to provide methods of handling many of the more tedious operations now requiring human effort.

TANKS FOR PREPARATORY PROCESSES

Equally important to the plating tank equipment are the several containers used for the preparatory processes. Tanks for pickling, acid dipping, potash solutions, hot water, and scouring are all necessary in the production of efficient work.

PICKLING TANKS

Foundry work, drop forging, drawn-steel work which has been annealed several times, and other heat-treated articles are usually delivered to the plating room with a surface coating of hard scale. While this scale may be removed by mechanical means, such as tumbling and sand blasting, a chemical process termed pickling, is often employed. The work to be cleaned is immersed in a weak acid solution until the scale or sand flakes off, or is dissolved. When it is not intended to pickle large quantities of work, or if the articles are small in size, a very suitable vat may be prepared from one-half of an oil or vinegar barrel. Usually, however, wooden tanks, such as described earlier in this chapter for plating work, are constructed especially for this chemical process. For cold pickling, an asphaltum lining is given to the tank. As is the case with most chemical solutions, action is quickened by heating. It is therefore advisable to heat the pickle bath by means of lead pipe steam coils placed in the bottom of the tank. Sufficient coil capacity should be provided to raise the temperature of the bath to approximately 200° F. The acid tanks may be lead lined for hot pickling, but this is not essential. It is best, though, to line the interior of the tank with light boards to protect the steam coils or, in the case of cold pickle tanks, the asphaltum. Regardless of the care exercised, castings will drop or baskets will strike the sides of the tank, causing damage unless the board protection is provided.

BRIGHT DIPPING TANKS

As will be explained later, tarnish and other light foreign matter may be quickly removed from the surface of metals by dipping in undiluted acid. This process is usually termed acid or bright dipping. Large tanks are seldom employed for this work on account of the cost of the acid. Stoneware containers, set under a hood and in a vat of warm water are provided. The plan view of such an arrangement

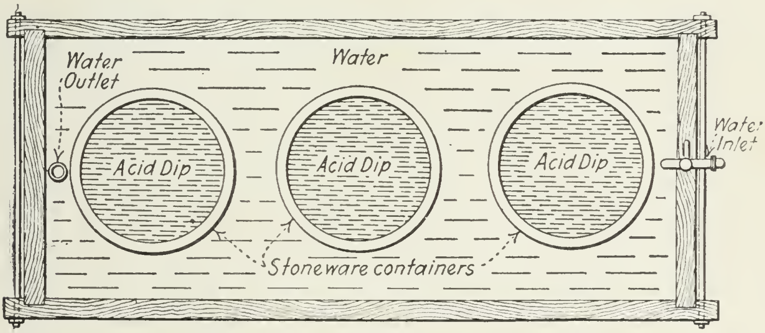


Fig. 68.—Bright Dipping Tank Showing Acid Containers and Water Bath

is shown in Fig. 68. One or more acid containers may be used, according to the shop requirements. The wooden rinsing vat is of construction identical to the plating and pickling tanks, with the exception of the water overflow. This device is merely a pipe passing through the bottom of the tank and with a height inside equal to the desired depth of water.

SPECIAL VENTILATING HOODS

During the bright dipping process, heavy poisonous fumes arise from the acid. A special ventilating hood is a necessity, therefore, to keep the air in the plating room free from these vapors. Fig. 69 shows a hood designed to be placed over the dipping tank

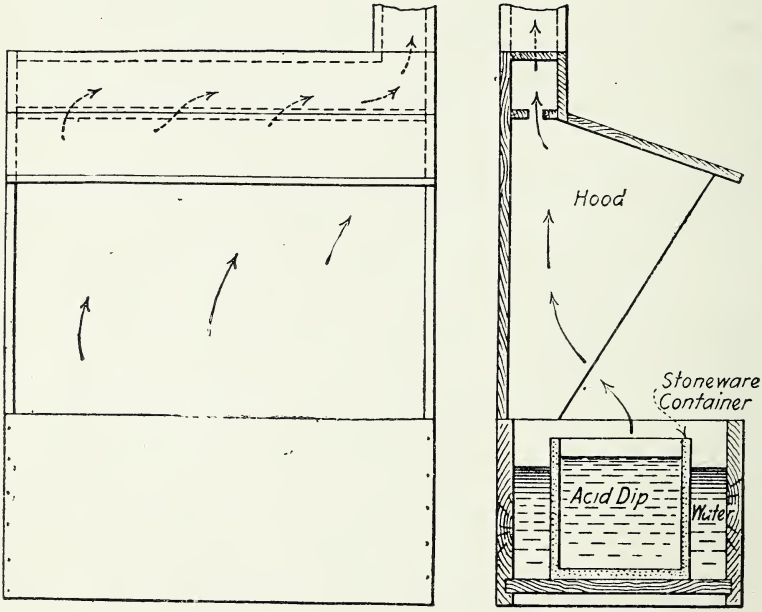


Fig. 69.—Acid Dipping Tank With Ventilating Hood

just described. It is constructed entirely of wood, preserved with asphaltum paint. It must be remembered that the acid fumes from the dips are much more concentrated than those collected from the plating tanks. The exhaust pipe, therefore, should not be constructed of metal but of wood or of glazed tile pipe. Wood is employed throughout in the hood shown here. The dimensions are dependent upon the available space; the plater can easily follow the general design, assigning such dimensions as are required.

LYE AND POTASH TANKS

Perhaps the most suitable tanks for lye and potash dips are of steel. Since the solution must be maintained at nearly the boiling point, steam coils should be provided. Jacketed tanks or kettles are even more satisfactory. No hood is provided for such dips.

HOT WATER TANKS

An unlined-wooden tank serves quite well for hot water, although a more expensive steel or iron container may, of course, be used. The hot-water temperature is maintained by the use of steam coils. Jacketed steel kettles are also excellent for such purposes. It is best, for the convenience of the plater, that an overflow pipe as well as a faucet connected to the fresh-water supply, be a part of the tank equipment.

SCOURING TANKS

The scouring and rinsing tank is always in constant use; practically every article to be plated must receive some degree of scrubbing or scouring. It is best, then, to place it centrally with respect to the plating tanks, and to so construct it that work can be done with little inconvenience. One suggestion is to raise the tank and scouring board to such a height that the plater can clean the work without stooping over. The tank is usually made of sound

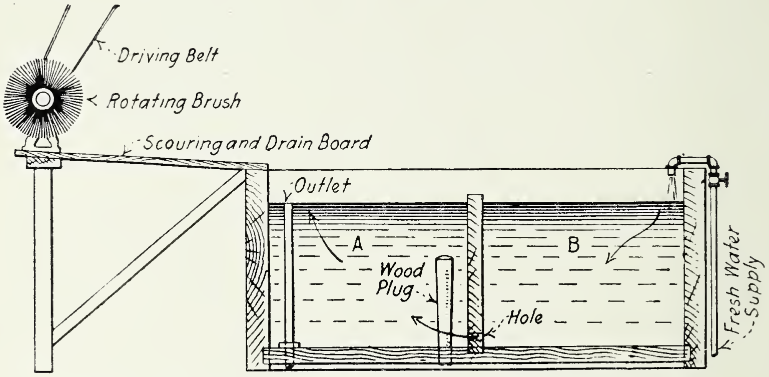


Fig. 70.—Scouring Board and Rinsing Tank

two-inch cypress boards and, with the exception of the lining, which is unnecessary in this instance, the construction is in general similar to the plating tank described in this chapter. The scrub board is located at one end of the tank and is so inclined that the surplus water drains back into the container. It is often advantageous to divide the tank by a wooden partition slightly higher than the excess water outlet, as shown in Fig. 70. A hole in the bottom section of the partition allows free flow of water from one side to the other. The work is first scoured on the board, then washed in the outlet compartment A, and finally rinsed in the fresh-water section B.

While most of the scouring is done with hand brushes, greater speed may be obtained if a small polishing head equipped with a rotating wire-scratch brush is mounted on the board. The increase in production will soon compensate for the additional fixture.

CHAPTER VI

MISCELLANEOUS PLATING ROOM EQUIPMENT

The Steam Generator—The Drying Oven—Hot Sawdust Box — Air Compressor — Time Dial — Plating Anodes — Flat Anodes — Corrugated Anodes — Elliptic Anodes —Curved Anodes — Slinging Wire — Plating Baskets — Plating Hooks—Plating Racks—Special Racks—Dipping Baskets—The Respirator—The Hydrometer—The Thermometer—Litmus Paper—Acid Pump—Carboy Inclinator—Speed Indicator—Clothing.

THE STEAM GENERATOR

The more important plating room equipment has already been described, but there are several miscel-

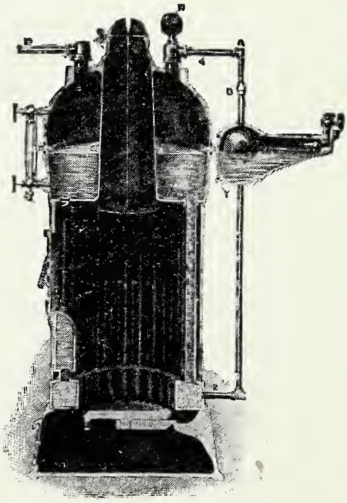


Fig. 71.—Modern Coal-Burning Steam Generator

(Crown Rheostat & Supply Co.)

laneous fixtures that should be considered before taking up the subject of the deposition process. Steam, for instance, plays an important part in plating-room operations. For the heating of electrolytes, pickles, lye dips, and water baths, as well as drying ovens and the hot sawdust box, steam is almost a necessity. Thus, where there is no source of steam supply, a low pressure boiler should be installed. The market affords a wide selection of such steam generators. A modern, automatic type, Fig. 71, uses coal as a fuel.

THE DRYING OVEN

Some types of work cannot be dried in sawdust and must therefore be hung in a drying oven until all traces of moisture have disappeared. Such ovens are manufactured, but since their construction is not difficult, it is suggested that the plater build one best suited to his particular requirements. The source

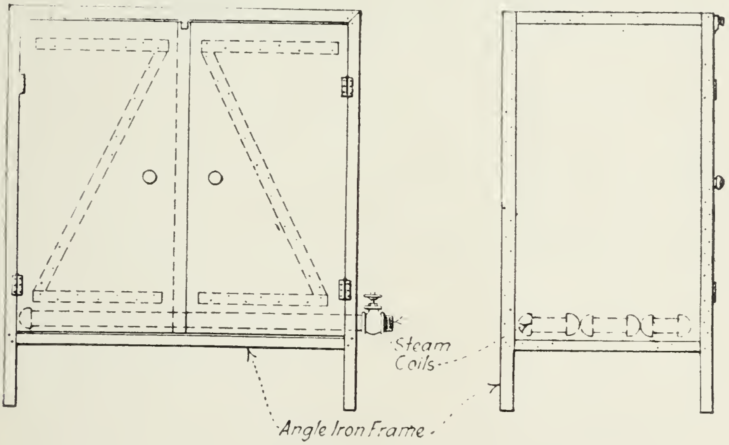


Fig. 72.—Steam Heated Drying Oven

of heat may be either gas or steam, though the latter is preferable. Fig. 72 presents a general outline of a steam-heated drying oven. The framework is of light angle iron, the adjoining pieces being bolted together. The walls, bottom, and top are of galvanized sheet iron, riveted to the angle iron framework. The doors are of slightly heavier sheet iron and are reinforced on the inside with angle-iron braces. They are hinged to the frame supports, as shown. Steam coils are placed in the bottom to furnish the necessary heat. The interior may be equipped with shelves or hooks, depending upon the character of work to be placed therein.

HOT SAWDUST BOX

One of the most convenient methods of drying quantities of small bright dipped or plated articles is to surround them with hot sawdust. The pieces are placed in a riddle, the meshes of which are smaller than the articles, and the sawdust poured over them. Shaking the riddle allows the sawdust, which has

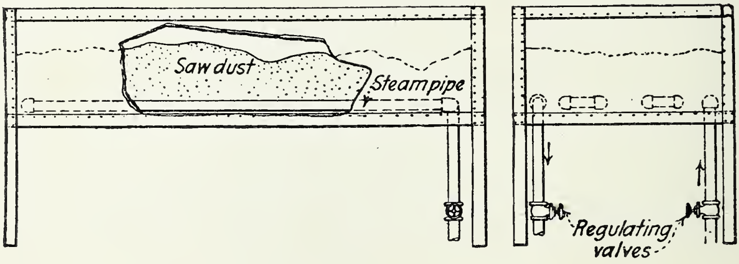


Fig. 73.—Side and End Views of Hot Sawdust Box, Showing Simple Construction

absorbed the moisture retained by the pieces, to fall through, leaving the work behind thoroughly dry. Box-wood sawdust is usually used for this operation because of its absorbent qualities.

As may be seen from Fig. 73, a hot sawdust box is easily constructed. Like the drying oven, the framework is of angle iron and the sides and bottom of galvanized sheet iron. Steam coils placed in the bottom supply the required heat. It must be admitted, however, that a manufactured box will be more substantially built and certainly more pleasing in appearance. There are several styles of these boxes on the market, the one shown in Fig. 74 being a good type.

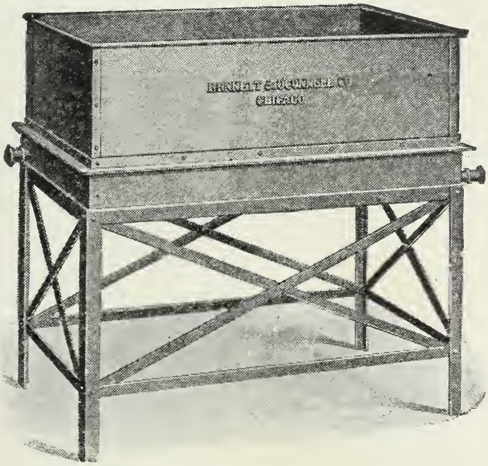


Fig. 74.—Hot Sawdust Box as Manufactured

AIR COMPRESSOR

As was stated in Chapter V, compressed air is used to advantage in the agitation of electrolytic solutions. The sand-blast machine, the lacquer spray, and several other devices also require air under pressure. Factories usually operate a large compressor which furnishes air to the plating room as well as other departments. Individual shops will, in many instances, have to supply their own compressed air. Before purchasing a compressor, a summation of all work requiring such service should be made to insure the selection of a machine of the correct capacity. The most economical method of driving the compressor is by an individual motor, thus eliminating all line shaft losses when the machine is idle.

TIME DIAL

A convenient method of denoting the time at which work should be removed from the plating tank is

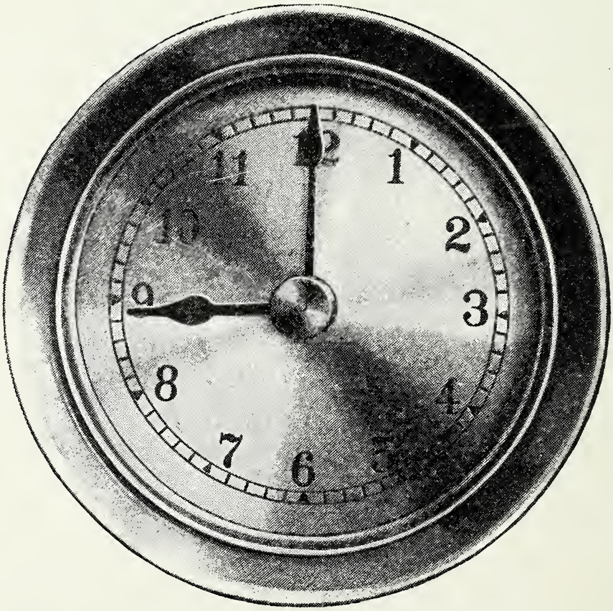


Fig. 75.—Time Dial

(Crown Rheostat & Supply Co.)

furnished through the use of a time dial, such as is shown in Fig. 75. A thumbpiece connects through the glass with the hands, allowing the latter to be set to indicate the hour and minute. If possible, a time dial should be placed above or on each active tank.

PLATING ANODES

There are several shapes and kinds of plating anodes on the market. Many of these are especially designed for certain classes of work. For this reason a brief discussion of the more important types is necessary.

FLAT ANODE

The flat anode was for many years the standard type used for all classes of work. While still popular, other shapes can now be adapted to greater advantage in many instances. For nickel plating cast anodes may be employed. A good point featured by several manufacturers is the use of either the separate or cast—in nickel hook. Other metals will, if allowed to stand in the nickel solution, act with a detrimental effect on the bath, preventing a clean, white electro-deposit. Furthermore, if the hook and the anode are of the same metal, the full surface may be immersed, thereby allowing an economy in material.

Copper and bronze anodes may also be plate castings. While brass anodes may be of rolled metal, castings are often preferred because of their solubility in the solution. Tin plates are also usually furnished in the cast form. Experience shows that the anode surface in the solution should be the equivalent of the area to be plated. On the other hand, silver and gold anodes need not present a surface area identical with the work. Of course, only anodes of pure metal should be used if good work is expected.

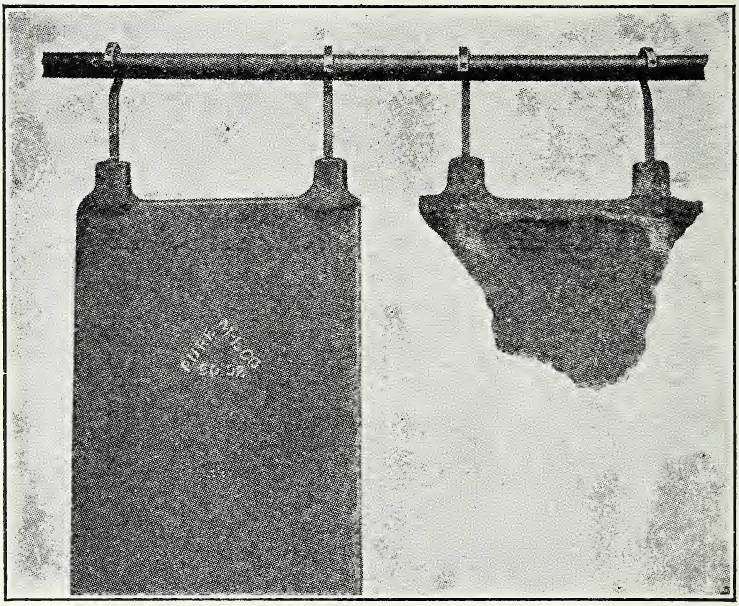


Fig. 76.—Characteristic Disintegration of Flat Anode. Note the Waste. The New Anode Weighed 22½ Pounds; the Stub Weighed 2 Pounds, 10 Ounces: Waste, 11.7 Per Cent. Compare this with the Two-Bar Type, Fig. 78

(A. P. Munning & Co.)

The characteristic disintegration of a flat anode is shown in Fig. 76 and shows amount to be considered as waste.

CORRUGATED ANODES

Quite similar to the flat-plate anode is that presenting a corrugated surface. The advantage of this type is the large exposed surface in comparison to the flat anode of equal width. This is a valuable feature in nickel plating, for since this metal does not readily dissolve, the large exposed area aids in maintaining the metallic strength of the solution without the addition of nickel salts. A corrugated anode is shown in Fig. 77.

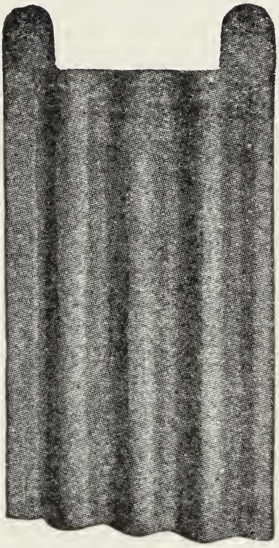


Fig. 77.—Corrugated Anode

ELLIPTIC ANODES

Anodes whose cross sections are round or elliptical in shape are finding favor in the plating room. The elliptical anode is especially featured by the producers for its economy and perfect plating characteristics. When there is poor, or no agitation of the electrolyte, it is noticed that the edge of a flat anode disintegrates more quickly than the center portion, and that the effect on the cathode is noticeable. The section of the cathode nearest the edges of the anode receives the heaviest deposit. The round or elliptic type of anode, however, allows an even disintegration with the resulting even deposit on the cathode. Thus, this type of anode can be left in the electrolyte until entirely consumed, this again showing a saving over the flat variety. Such a round section anode, in the two-bar form, is shown in Fig. 78.

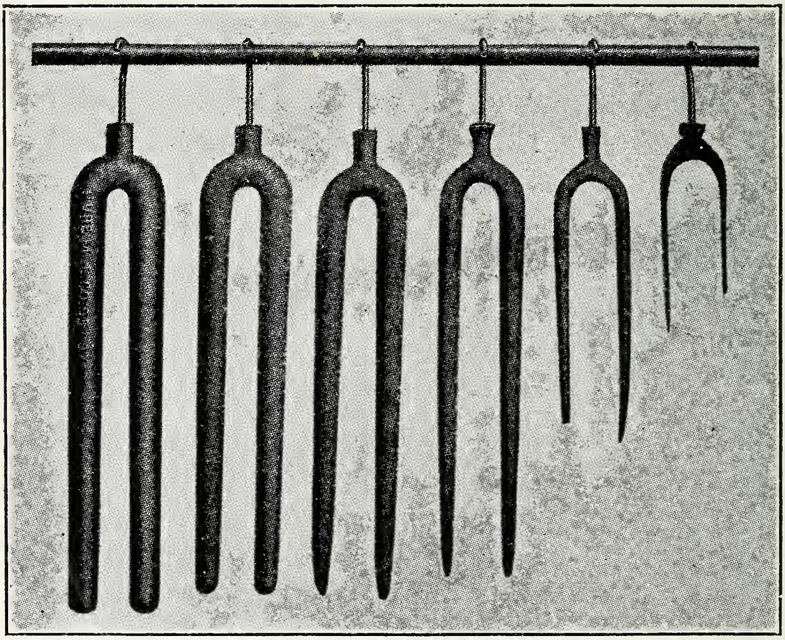


Fig. 78.—Characteristic Stages in the Disintegration of 2-Bar Anodes. Note the Uniform Wearing Qualities. The Nickel Anode on the Left Weighed 14 Pounds, that on the Right, in the Last Stage of Disintegration, Weighed 8½ Ounces. Waste 3.8 Per Cent

(A. P. Munning & Co.)

CURVED ANODES

Special work or mechanical plating machinery may require anodes which are curved. For instance, revolving, horizontal plating barrels, such as described in Chapter V, produce a more uniform deposit on their contents when a row of curved anodes is placed on either side, allowing an equidistant anode surface on the bottom as well as on the sides of the work.

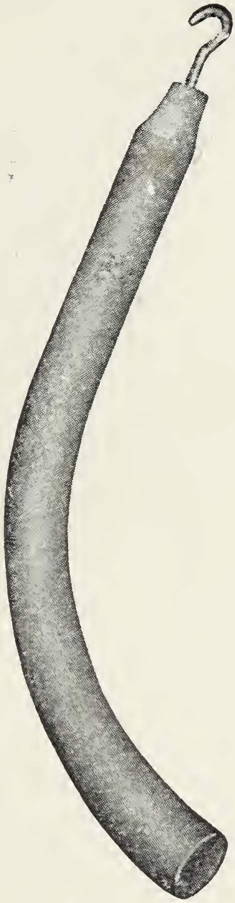


Fig. 79.—Curved Anode, Circular Cross Section

Other forms of anodes are available and may, no doubt, be used with satisfactory results. In selecting an anode, regardless of shape, special attention must be given to the actual active surface that will be available. It is the active or submerged surface that is valuable; all else is a useless and needless expense. The curved anodes in Figs. 79 and 80 are the types used with plating barrels.

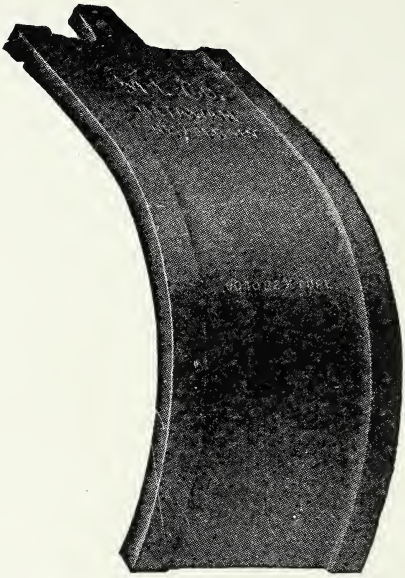


Fig. 80.—Curved Anode, Rectangular Cross Section

SLINGING WIRE

The usual agent employed in suspending light-weight work in the electrolytic solutions is copper wire. Each article is securely fastened with a length of copper wire, the latter then being wrapped several times around the cathode rod to form an electrical connection when the cluster is hung in the tank. Several times during the plating process the point of fastening of the wire to the article should be changed. The danger of an uneven deposit on the surface covered by the wire is then avoided.

PLATING BASKETS

Small articles may be plated in quantities in a wire tray or basket. The result obtained by this method will not, of course, compare favorably with that secured on the individual wire slung pieces. But, because of the convenience and time saved, the basket

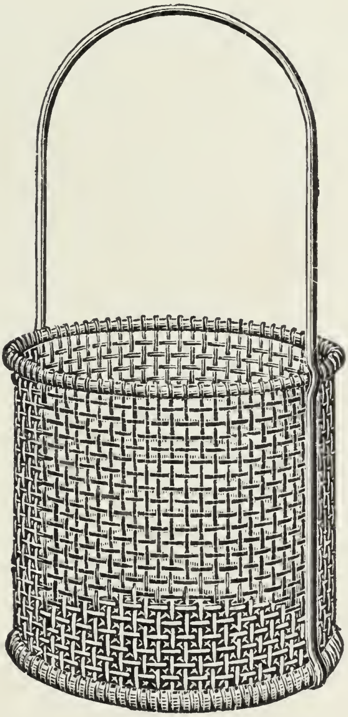


Fig. 81.—Cylindrical Shaped Wire Plating Backet

process is sometimes resorted to where the only purpose is protection from rust or tarnish, and not improvement of appearance. Even in this case, it is necessary to occasionally shake the basket, when it is suspended in the plating tank, so that the contents may so change their relative positions that a fairly even deposit is assured. A typical plating basket suited for a variety of work is depicted in Fig. 81.

PLATING HOOKS

Large or heavy articles are often suspended in the plating bath with copper hooks; one loop is attached to the work, while the other loop is placed over the cathode bar. The design of the hooks, as well as the gauge of the material used in their construction, depends upon the class of work handled. It is well to have an assortment of hooks on hand so that any

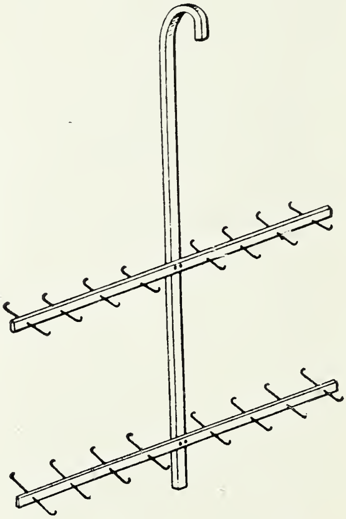


Fig. 82.—Plating Rack

size of article may be placed in the tank on short notice, if necessary, without the delay of forming the proper hook for it.

PLATING RACKS

A plating rack affords the most convenient method of individually suspending quantities of small parts in a still tank. Such racks are not difficult to construct, and they eliminate the necessity of employing wire or a separate hook for each piece of work. In general, a rack consists of a copper rod to which cross-

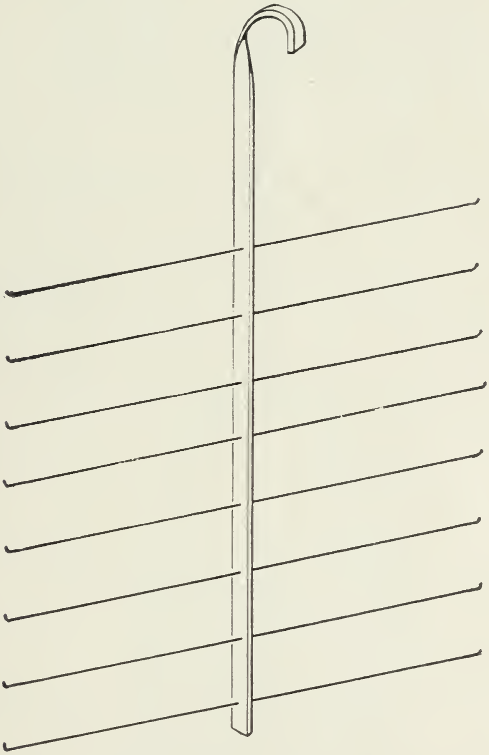


Fig. 83.—Rack for Plating Large Quantities of Small Parts, a Number of Which are Strung on Each Horizontal Wire

pieces of the same material are riveted and soldered. The crosspieces are provided with hooks to hold the articles while the supporting rod has one end so formed that it may hang over the cathode rod. Often two supporting rods are furnished, thereby increasing the rigidity of the rack. Note the illustrations in Figs. 82 and 83, which show simple plating racks, and that in Fig. 84, which shows a special type having a double support.

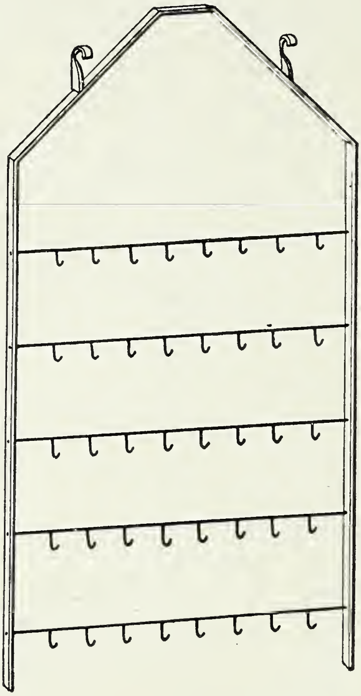


Fig. 84.—Double Support Plating Rack for Small Articles

SPECIAL RACKS

The electroplater is often called upon to finish castings of unusual shapes, drawn metal parts, or pipes. If a deposit on the interior surface is expected, special racks providing a separate anode must be used. The plater must exercise his ingenuity in designing such racks, keeping always in mind that quickness in adjusting the work in the rack or removing it is as essential as is the securing of a good deposit. This is particularly important in the handling of large quantities of commercial work.

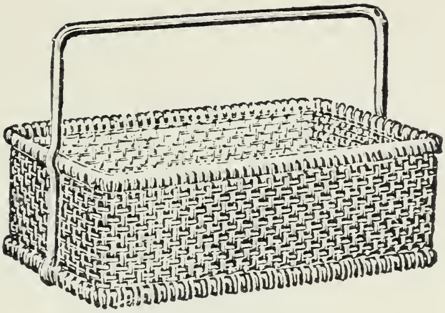


Fig. 85.—Rectangular Shaped Wire Dipping Basket

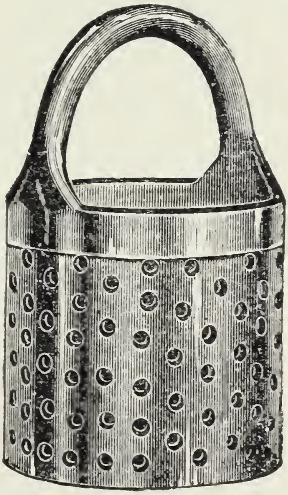


Fig. 86.—Stoneware Dipping Basket. Straight Type

DIPPING BASKETS

While wire hooks may be employed in acid-dipping work, greater convenience is found in the use of stoneware or wire dipping baskets. Stoneware baskets are heavy and subject to breakage, but they can be used without the danger of disintegration in acids or potash. Wire baskets, on the other hand, are light in weight as well as durable, but cannot be subjected to acids for any great length of time. Aluminum wire baskets or trays, for example, are affected to some extent by both potash and muriatic acid, but are nevertheless quite popular on account of their exceedingly light weight. Brass and steel wire baskets are also manufactured for dipping operations. A rectangular shaped wire dipping basket

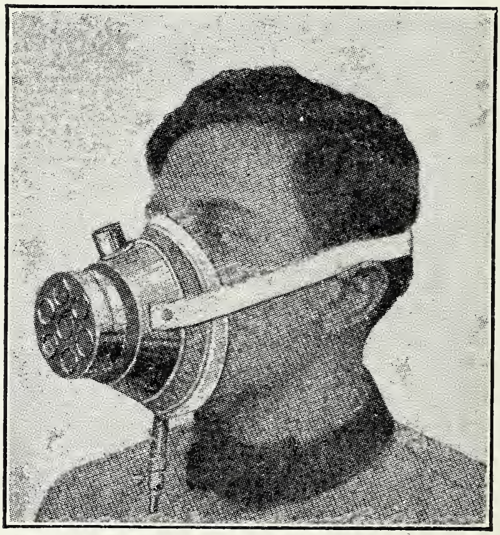


Fig. 87.—Respirator

(Mott Sand Blast Mfg. Co.)

is outlined in Fig. 85, and a straight type stoneware dipping basket is shown in Fig. 86.

THE RESPIRATOR

As a protection against inhaling poisonous fumes or injurious abrasive dust, a filter mask or respirator is often used. This device is worn strapped in such a position that it effectively covers the nose and mouth, allowing no air to enter except that which passes through a filter, such as a wet sponge. Exhaled air escapes through an automatic valve in the side. It is, of course, understood that if suitable ventilating equipment is provided for the plating and polishing rooms, there is little necessity for wearing a respirator. A respirator, as it looks when worn by the operator, is shown in Fig. 87.

THE HYDROMETER

A hydrometer is a device for measuring the specific gravity, the relative density, of solutions. In appearance it is similar to a thermometer glass with the exception of the bulb which is filled with lead shot instead of liquid. The scale markings are, of course, laid off to a different standard. By allowing the hydrometer to float, bulb downward, in a test tube or other container of any solution, the density

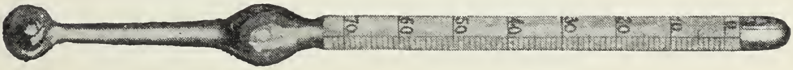


Fig. 88.—A Hydrometer For Testing the Density of Plating Solutions

(Crown Rheostat & Supply Co.)

of the latter is found by noting the scale reading at the solution surface level. An acid Baumé hydrometer with a scale of 0°–20° is adequate for most plating solutions, although a scale of 0°–70° is necessary for acid and acid dips. Undoubtedly the hydrometer is most valuable in testing nickel electrolytes. A registration at 6° to 8°, for instance, indicates a good solution, while any point showing below 6° warns that the bath is becoming weak in metal and requires the immediate addition of nickel salts. The simplicity of the hydrometer for testing the density of the plating solutions is shown in Fig. 88.

THE THERMOMETER

For determining the temperature of hot solutions, a thermometer having a scale reading up to 212° F., or higher, is often useful. Again, a thermometer is of assistance to the plater in maintaining an even temperature in the drying oven or lacquer room. The glass thermometer, shown in Fig. 89, is for hot solutions.

Fig 89.—Glass Thermometer for Hot Solutions

(Crown Rheostat & Supply Co.)

LITMUS PAPER

Certain vegetable substances have the property of changing color when acted upon by acids or alkalies. One of these is litmus, which in acid solutions is red, and in alkaline, blue. The plater will find it to his advantage to provide himself with filter paper treated with litmus, known commercially as litmus paper. If a drop of the solution, whose reaction is unknown, is placed on a sheet of blue litmus paper, that portion affected will turn light red, if the solution is even slightly acid.

ACID PUMP

Among the daily duties of an electroplater is the handling of concentrated acids. This is a dangerous task, particularly the emptying of heavy carboys, unless some device is available to mechanically remove the acids from their containers. One of these devices is the acid pump. A rubber plug, through which a long and short tube passes, is substituted for the commercial stopper. By the use of a small hand-

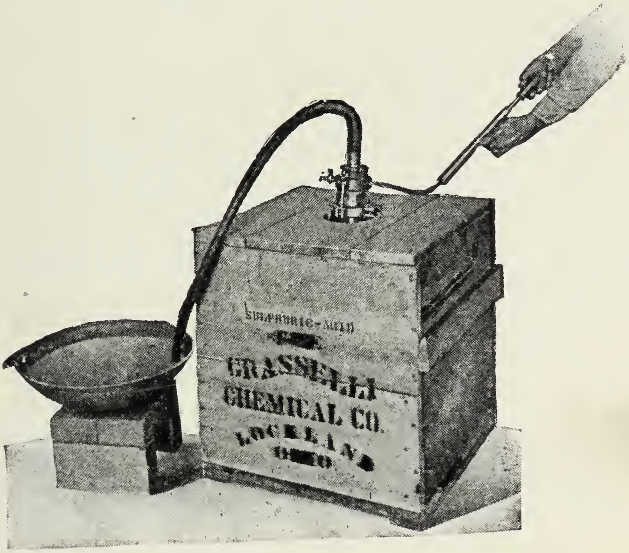


Fig. 90.—Non-Corrosive Acid Lift for Carboys

(General Platers' Supply Co.)

pump connected to the short tube, the air pressure on the interior of the carboy is increased. The acid is thus forced up the long tube and passes out into a pitcher or other container. Note Fig. 90.

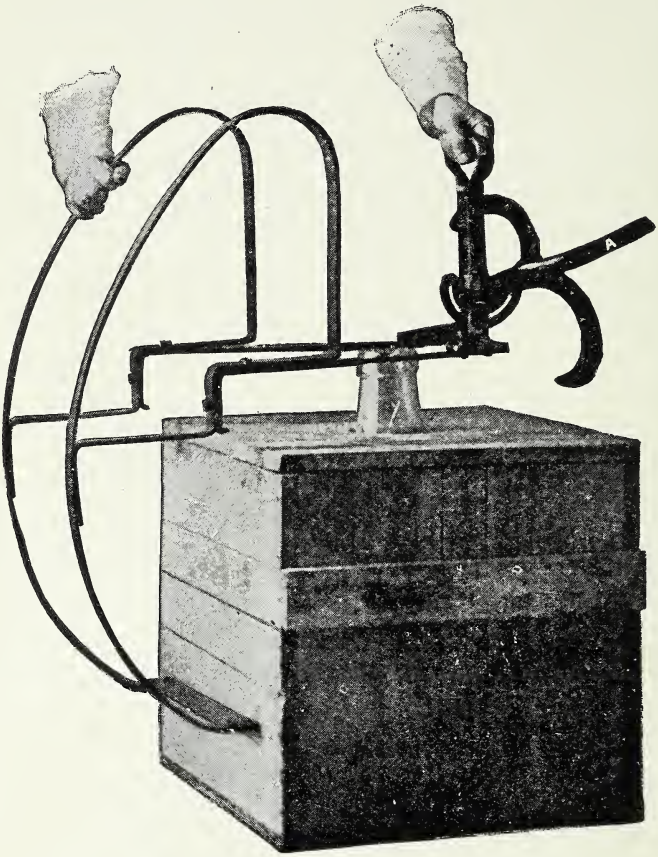


Fig. 91.—Carboy Inclinator

(General Platers' Supply Co.)

CARBOY INCLINATORS

Another apparatus, which is, perhaps, more extensively used than the acid pump, is the carboy inclinator. There are many designs on the market, but the essential principle is the same for all; the carboy is rocked forward to the necessary angle on a portable adjustable frame, the acid pouring from the neck mouth into the provided container. Fig. 91 illustrates this device.

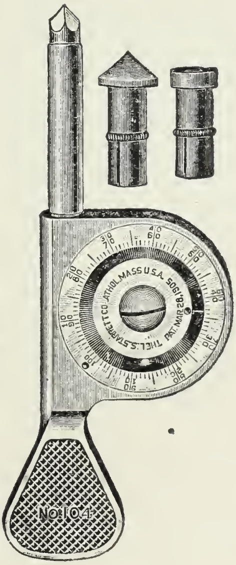


Fig. 92.—Speed Indicator

(L. S. Starrett Co.)

SPEED INDICATOR

The plating generator should always be driven at the speed specified on its name-plate. The only sure method of determining whether this speed is maintained is through the use of an indicator. There are many designs available, ranging from the simple revolution counter to the carefully adjusted electrical speed indicator. For plating and polishing room use in determining the speed of motors, generators, shafting, buffing and polishing wheels, and the like, the most simple and inexpensive type of speed indicator will suffice. A very simple yet accurate instrument is shown in Fig. 92.

CLOTHING

While it is almost impossible to fully safeguard the clothing from acid burns, some protection is provided when rubber aprons, rubber gloves, and heavy shoes are worn. If the plating room floor is constructed as suggested in Chapter III, much relief from dampness will be enjoyed. Shoes with wooden soles may be obtained for use in rooms where water and acid are not drained from the floor.

CHAPTER VII

THE PREPARATION OF WORK FOR ELECTROPLATING

Cleansing—Removal of Burrs—Oblique Tumbler—Horizontal Tumbler—Charging the Tumbler—Sand Blasting—Two-Hose Sand Blast—Single-Hose Sand Blast—Sand Blast Room—Automatic Sand Blast—Sand Blast Rolling Barrel—Rotating Table Sand Blast—Compressed Air Supply—Sand Blast Sand—Cleansing by Pickling—Rinsing—Electrolytic Cleaning—Copper Striking—Polishing—Hot Lye Dipping—Scratch Brushing—Scouring—Removing Oxides — Stripping — Non-Metallic Work — Bright Dipping.

CLEANSING

The preparation of an article for electroplating requires more hard work than skill, yet the succeeding plating operations cannot be successful if the first cleansing process is slighted. Grease, scale, or rust on the surface of an article acts as an insulator against the passage of electricity and causes, at the best, a faulty deposit of metal. Under no circumstances should even the fingers touch the prepared work in placing it in the tank.

An electro-deposit will not efface scratches or flaws in the metal; the original surface must be smooth if the plated finish is to show no imperfections. All metals cannot be treated exactly alike, as experience shows, yet the essential operations are somewhat similar.

REMOVAL OF BURRS

Rough castings or other articles must, of course, be ground on an emery wheel to remove the heavy burrs. If the burrs are quite small and sharp, the castings may be shaken in a tumbling barrel. This operation not only removes the burrs but quite often the scale, sand, and rust. Obviously, no work having sharp corners that are to be preserved should be put in the barrel. One important advantage of tumbling is the amount of time and labor saved. After the work is placed in the barrel, no further attention need be given to it until the articles are completely burred and cleaned.

OBLIQUE TUMBLER

Small articles, not of a fragile nature, may be perfectly cleaned in an oblique tilting tumbler, such as that shown in Fig. 93. Metal barrels of sheet steel, cast iron, or brass are usually preferred to the less durable wooden type. As may be noted, the barrel can be tilted while revolving—backward when tumbling work and forward to eject it. The objects being tumbled may be inspected at any time without stopping the machine.

HORIZONTAL TUMBLER

The horizontal tumbling barrel is designed for larger work than that handled by the tilting type. Often there are two compartments, each furnished with a door which is bolted firmly in place. There are several types of horizontal tumblers on the market but all operate on the same basic principle.

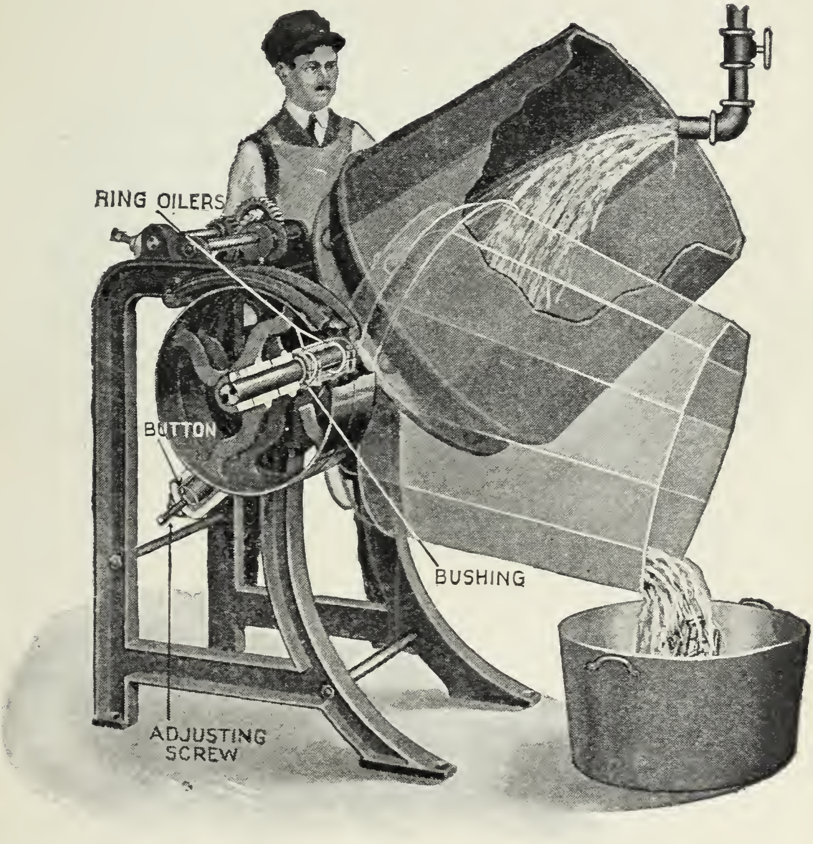


Fig. 93.--Oblique Tilting Tumbler

(The Baird Machine Co.)

Tumbling barrels are, of course, power-driven, control being secured through the use of tight and loose pulleys. The horizontal tumbling barrel shown in Fig. 94 is well adapted for handling heavy pieces.

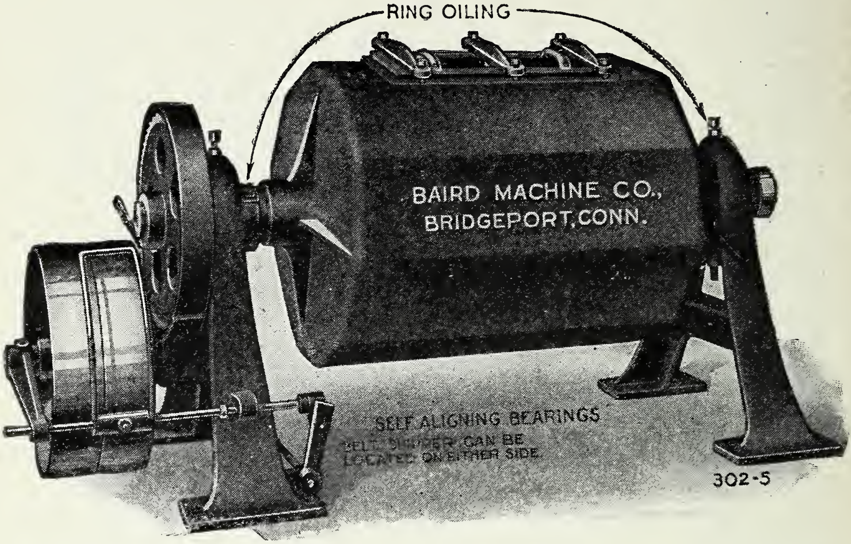

RING OILING
BAIRD MACHINE CO., BRIDGEPORT, CONN.
SELF ALIGNING BEARINGS
BELT SHIPPER CAN BE LOCATED ON EITHER SIDE
302-5

Fig. 94.—Horizontal Grinding Barrel for Tumbling Heavy Pieces

(The Baird Machine Co.)

CHARGING THE TUMBLER

Sawdust is perhaps the cheapest absorbent agent available for the tumbling process. The barrel, regardless of type, is generally charged with an equal quantity each of work and sawdust. Under no circumstances should the drum be run more than two-thirds full. The sawdust absorbs the grease and moisture, while the rubbing action of the pieces removes the dirt, rust, and sharp edges.

In some cases it may be necessary to employ abrasives such as gravel, broken glass, metal chips, sand, or pumice. The choice of the abrasive must, of course, depend upon the softness of the metal articles to be tumbled. Steel ball burnishing, which is another form of tumbling, will be described later.

SAND BLASTING

Light, fragile articles, which might be broken if tumbled, may be quickly cleaned by sand blasting. While tumbling or pickling processes require a certain amount of time, sand blasting produces a surface free from all grease or scale in a few minutes, regardless of the size or shape of the article.

Sand blasting, as the term implies, is the cleaning of any object with a stream of sharp sand driven from a nozzle by air pressure. The sand, striking the surface of the object with great force, produces a cutting action which effectively removes all foreign matter.

TWO-HOSE SAND BLAST

Perhaps the most simple type of sand blasting device consists of a Y-shaped nozzle, an air hose and valve, a sand hose, and the necessary helmet for the operator. The nozzle tip, which is the bottom part of the Y, is hardened to reduce excessive wear and may be quickly removed and replaced. One of the upper branches of the Y is connected through a hose to an air supply of 50 to 60 pounds. The nozzle air pressure is regulated through a conveniently placed valve. The opposite branch of the Y is connected through a rubber hose to a sand container, such as a box or pail. When the air is allowed to flow, a stream of sand is drawn into it, the mixture passing from the nozzle as a sand blast. While the reference is made to the letter Y for descriptive purposes, manufactured nozzles are, of course, constructed more compactly.

SINGLE-HOSE SAND BLAST

Two-hose sand blast nozzles are cumbersome and difficult to handle. Accordingly, a single-hose apparatus is available where the sand and air are mixed in a compartment before entering the single

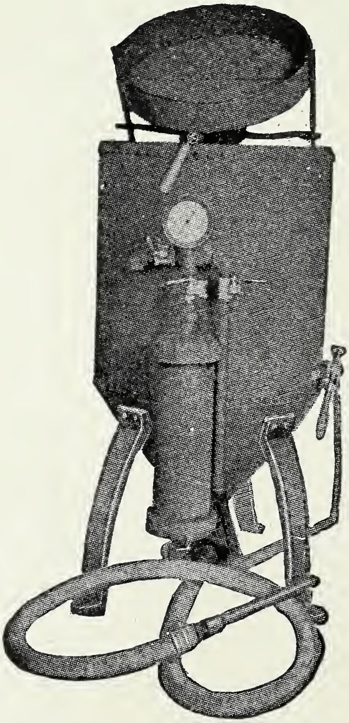


Fig. 95.—Single-Hose Direct-Pressure Sand Blast Machine.

(Mott Sand Blast Mfg. Co.)

1 inch hose provided for the operator. This hose is specially constructed to resist the wear of the sand and for most work a ¼ inch single nozzle with a hard tip is provided. A single hose direct pressure sand blast machine is shown in Fig. 95.

SAND BLAST ROOM

The use of the sand blast apparatus just described requires a special work room. If possible, the location should be such that the fine sand particles, which escape from the room in spite of precautions, do not settle on machinery, plating solutions, or recently lacquered articles. The bench, on which the work to be cleaned is placed, may be made of iron bars, thus allowing the escaped sand to pass through and into a container beneath. The walls on each side of the bench where the sand particles are apt to strike, should be protected with sheets of iron. Directly above the bench a hood should be placed, connected to a ventilating blower.

It is quite difficult to obtain men who will operate the foregoing apparatus. The sand blast clothing equipment is uncomfortable, especially during hot weather when the confinement in a closed room, with hot, heavy gloves on the hands, and stuffy helmet over the head, imposes severe hardship on the workman. The present-day tendency is toward the use of self-contained dust proof, automatic sand blasting machines.

AUTOMATIC SAND BLAST

One type of such a machine is shown in Fig. 96. It has a sand blast compartment of heavy sheet iron in which are glass windows to enable the operator to view the work. Large articles undergoing sand blasting are placed in or removed from the compartment through a side-door. Small articles may be thrust through the front hand holes. It is seen that these openings have cloth protectors to prevent injury to the workman's arms while the blast is in operation. Upon pressing the foot lever, the air valve is opened, allowing a blast of sand to be expelled against the work, which is held in the necessary positions until

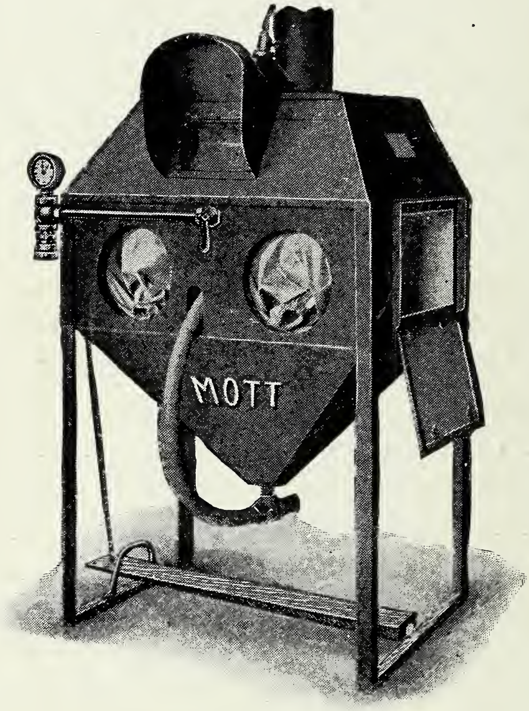


Fig. 96.—Sand Blast Cabinet
(Mott Sand Blast Mfg. Co.)

a clean, matt finish on all surfaces is assured. The used sand drops back into the lower container where it is again drawn upward through the sand pipe on another cycle of work. Often a wire mesh is provided at the top of the sand container to catch any articles accidentally dropped from the hands.

SAND BLAST ROLLING BARREL

Another device manufactured for automatically sand blasting small work is the rolling barrel. This apparatus, when filled with castings, forgings, or other metallic articles, effectively cleans all surfaces without the supervision of an operator.

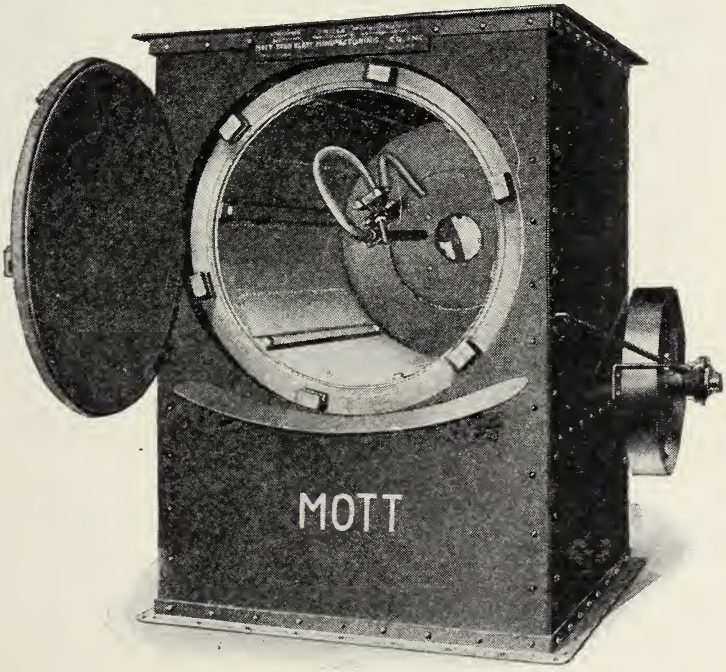


Fig. 97.—Sand Blast Tumbling Barrel

(Mott Sand Blast Mfg. Co.)

The machine is not unlike a horizontal tumbling barrel in appearance and action, but with the addition of the sand blasting features. An end opening is provided in the barrel in place of the usual side-door found on tumblers. Inside of the main barrel is a cylinder, several inches smaller in diameter, and constructed of perforated steel. Fixed in a position near the top of the inner cylinder are the sand blast nozzles. Work is placed in the steel cylinder, the end cover put in position, and the machine started. While it revolves at approximattely 2 r.p.m., thereby slowly rolling the articles in the barrel, the blast reaches every section of their surfaces, removing foreign matter. The used sand falls through the perforations in the cylinder to the space between it and the barrel. Buckets similar to those used on the old type water wheels, attached to the revolving barrel, carry the sand around the circle until it is emptied into the sand container above the nozzle. A typical sand blast rolling barrel is shown in Fig. 97.

ROTATING TABLE SAND BLAST

A third type of sand blast machine is shown in Fig. 98. As is indicated, the table revolves, carrying work placed upon it beneath a sand blast. The work passes through split curtains, these latter preventing the escape of abrasive material to the outside of the blasting chamber. The natural advantage of this machine over other types is that the operation is continuous, the work being loaded onto and removed from the exposed half of the moving table.

COMPRESSED AIR SUPPLY

If compressed air is available, as is the case if the sand blast machine is located in a large factory, special blowers are not required. Otherwise a compressed air plant must be installed. It is suggested that a reserve air tank be added, this to be charged when needed, and the supply of compressed air thus always available can be used to advantage for agitating plating solutions, or for drying work taken from the final hot water dip. It is best to locate the compressor in a dry place, free from dust. Wet air re-

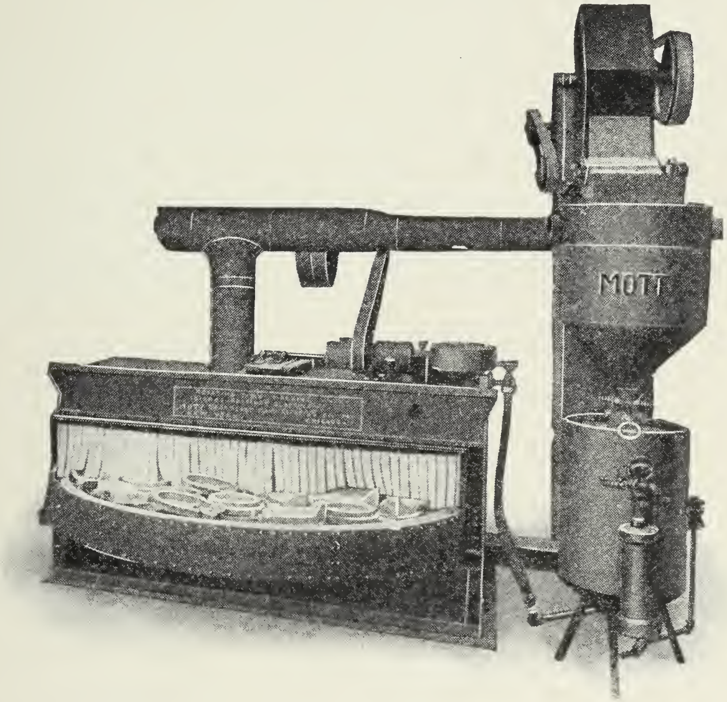


Fig. 98.—Rotating Table Machine Direct-Pressure Blast

(Mott Sand Blast Mfg. Co.)

duces the efficiency, and perhaps may stop entirely the operation of the sand blast machine.

SAND BLAST SAND

Some words of caution in the selection of the sand may be advisable. Not all grades of sand can be used with success. Usually a hard, clean silica sand is the best. The grains should be uniform in size and in texture though sharp sand is not necessary, as the edges soon wear off. Above all, the sand must be perfectly dry when placed in the blasting machine, even if it is necessary to heat it in order to remove all the moisture.

CLEANSING BY PICKLING

But tumbling, sand blasting, and other mechanical cleaning machinery is not always available for the removal of foreign substances from the surface of articles to be plated. In many instances, therefore, it is necessary to prepare the work by pickling. This process is one where the scale or other undesirable substance is removed from the metal surface by the chemical action of an acid. Sulphuric, hydrochloric or muriatic, and hydrofluoric acids, diluted with water, are the ones used to the greatest extent. Compounds are also manufactured which can be dissolved in water, and employed with the same success as acids. Pickle baths for iron articles are made by adding one part of sulphuric or muriatic acid to fifteen or twenty parts of water. The acid should always be added to the water; never the water to the acid. Brass work requires a slightly weaker solution of sulphuric acid to obtain the best results. Hydrofluoric acid may be used in a very diluted form, if necessary. Its function is to dissolve the sand adhering to the castings yet without injury to the iron. A quick pickle for iron castings, which may be used cold or hot with good results, is composed of 20 parts water, 2 parts muriatic acid and 3 parts hydrofluoric acid.

The work is strung on wires and suspended or placed in the pickle. Care must be exercised to prevent over-pickling, which causes seams and roughness on the surface of the work. Warm pickle baths, of course, act with greater rapidity, but the acid fumes arising from the tanks are more dense.

RINSING

Immediately after removal from the pickle, the work is rinsed in cold water to remove all traces of the acid, and then dipped for a few moments in hot water. The purpose of the hot water treatment is to give the articles sufficient heat to dry quickly without forming rust.

ELECTROLYTIC CLEANING

Before passing on to a description of the final cleaning operations, some mention should be made of the electrolytic cleansing process. This method is rapidly gaining favor since it removes the foreign substances in much less time than the pickling bath, and lessens the labor of scouring.

Usually steel tanks are employed since they can then be conveniently used for the anodes, being connected to the positive terminal of the generator circuit. The electrolyte is an alkaline solution, such as caustic soda, kept near the boiling-point by means of steam coils. The work to be cleaned is treated as a cathode and is, therefore, connected to the negative bus bar. An e.m.f. of 6 volts is sufficient, providing the current density is not less than 12 amperes per square foot. As might be expected, an increase in current density quickens the cleaning action. Large quantities of hydrogen gas are thrown off from the surface of the work, removing all traces of oxide and grease. Only a few minutes are required for this process, which is shown in diagram form in Fig. 99.

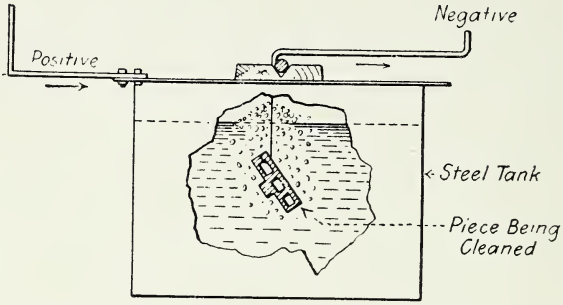


Fig. 99.—Electrolytic Cleaning. A Similar Process is Employed in Copper Striking

COPPER STRIKING

Copper "striking," or "flashing," is another favorite method of cleaning metal work. One advantage of this process is that a thin film of copper is deposited on the article, a perfect coating denoting a chemically clean surface. Upon this coating another metal may be deposited with excellent results. As in the process described in the paragraph on electrolytic cleaning, a steel tank, being positive, serves as the anode. The article to be cleaned is connected to the negative terminal. An alkaline copper bath is used. Such an electrolyte may be prepared to suit the requirements of the work from a mixture of water, copper cyanide, sodium cyanide, and caustic soda. A copper deposit, under such conditions, forms in a few moments.

POLISHING

Should the work now present a rough surface where a fine smooth one is desired, a polishing operation is added. When the polisher has secured the desired grade of finish, the work is passed on to the plating room for the final cleaning operations, preparatory to entering the electrolyte. A discussion on polishing and grinding is given in Chapter IX.

HOT LYE DIPPING

For steel and iron pieces, the next step is an immersion, for 15 to 30 minutes, in a hot lye or caustic soda solution. While the strength of this solution may be varied to suit the character of the work, one part of lye to 40 parts of water by weight, proves sufficient for the average requirements.

For quick and positive results it is essential that the lye bath be maintained at nearly a boiling temperature. This is accomplished by the use of steam coils, as is indicated in Chapter V. After removal from this tank, the work is thoroughly rinsed in cold water and taken to the scouring bench.

SCRATCH BRUSHING

Scratch brushing and scouring produce in general the same effect, the former being slightly more severe.

The scratch brush is constructed of fine metal wires and is driven by mechanical power. Obviously, to secure desired cleansing results, the scratch brush wires are composed of a material harder than the surface being worked on, these being held by a wooden center hub, as shown at Figs. 100 and 101.

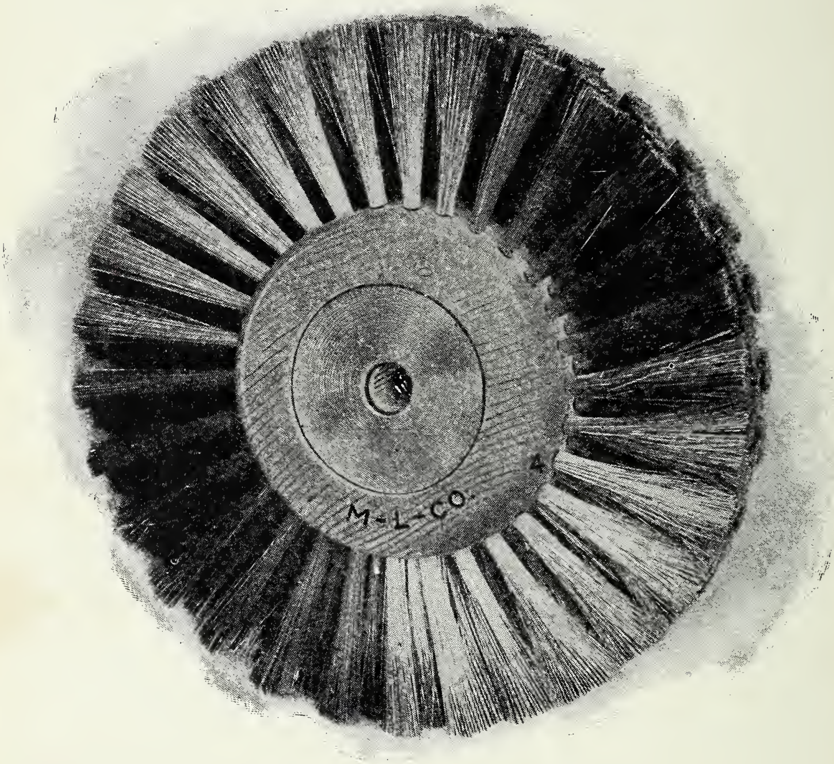


Fig. 100.—Circular Steel Wire Scratch Brush
(A. P. Munning & Co.)

SCOURING

For scrubbing or scouring, fine pumice and water is often used. Although a hand brush can be employed for most work, greater production in less time is obtained through the use of a power-driven rotary brush. This brush may be mounted with its lathe on the scouring board as suggested in Chapter V. The work of scouring is continued until the entire surface to be treated is as bright, clean and smooth as it is desired that the finished plated surface should be.

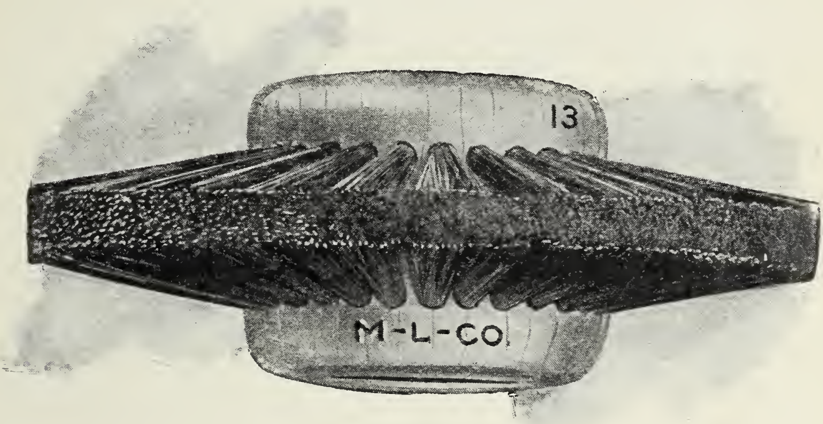


Fig. 101.—Small Circular Black Bristle Brush

(A. P. Munning & Co.)

REMOVING OXIDES

When the articles are as clean as scouring can make them, they should be rinsed thoroughly in cold water and given a quick dip in muriatic acid. Upon rinsing them again in cold water, an inspection should be made prior to hanging them in the plating tank. Since moisture does not readily adhere to an oily surface, the appearance of dry spots on the work after rinsing indicates improper cleaning. Obviously, in such instances, the cleaning operation should be repeated to remove the grease. Work that is held out of the solution will oxidize quite rapidly. This final acid dip, preparatory to the plating operation, is, therefore, a precautionary measure to remove all possible existing oxide. No time should thus be lost in placing the work in the electrolytic solution after it has passed through the last rinsing water.

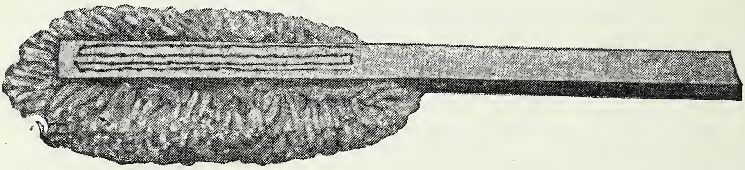


Fig. 102.—Cotton Potash Brush

(Crown Rheostat & Supply Co.)

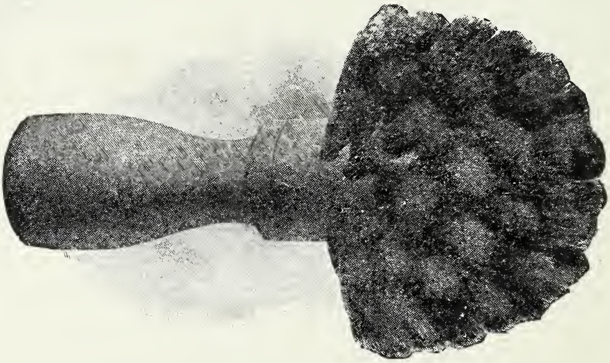


Fig. 103.—Goblet Shaped Brush

(General Platers' Supply Co.)

The same general operations may be followed for cleaning brass and copper objects with the exception of the final acid dip. To remove the oxide accumulation, a potassium cyanide dip is substituted for the muriatic acid. After rinsing in cold water, the work is immediately placed in the plating tank. It might be worth mentioning that finely polished brass and copper articles rarely require scouring, but this is, of course, a question to be decided by the plater. A variety of scouring and cleaning brushes, for different classes of work, are shown in Figs. 102, 103 and 104.

STRIPPING

It is not unusual in the production of commercial work to discover, after plating is completed, that some mechanical operation has been omitted or that, through accident, perhaps, the original finish is damaged. Before replating can be properly accomplished, the old deposit must be removed. Especially is this true of nickel or silver work. Two methods are available: the old deposit may be removed by acid dipping, or else stripped electrically by reversing the current direction, thereby using the articles as an anode.

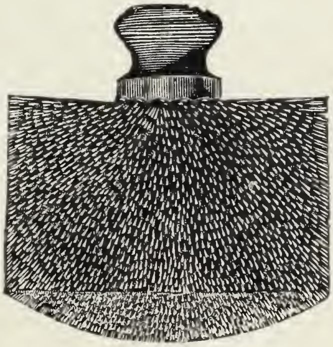


Fig. 104.—Brush for Cleaning the Interior Surfaces of Vessels

(General Platers' Supply Co.)

Copper or brass plating is most easily removed by dipping the work in a hot solution of sulphuric and nitric acids mixed in a proportion of approximately six to one by volume. Rinse in hot water after dipping.

A good stripping solution for nickel finishes is composed of one part each, by volume, of water, sulphuric acid, and saltpeter (sodium nitrate). Nitric acid may be substituted for the saltpeter, but in proportion one-fourth that of the sulphuric acid. During the stripping process, continue to move the work back and forth through the solution. Rinse in hot water immediately after removal from the dip.

Silver may also be removed from copper alloy articles through the use of an acid dip. A hot solution of two parts sulphuric acid to one part saltpeter gives good results.

Silver may be stripped from iron and steel articles by utilizing a reverse current of about two volts, the articles forming the anodes, and one of the regular silver anodes forming the cathode. A stripping solution for this process is:

Water	1 gal.
Potassium cyanide	8 oz.
Silver chloride	½ oz.

NON-METALLIC WORK

Articles which are non-conductors of electricity may be so treated that a metallic deposit can be formed on their surfaces. The purpose of such work may be commercial, artistic, or sentimental in nature. Metal-coated wood and leather work, porcelain or pottery has commercial value. Metalized flowers, insects, leaves and the like, can be fashioned into novelties or jewelry. Keepsakes, such as baby shoes, can also be preserved if covered with a thin coating of copper or silver.

Large, stable articles, after being thoroughly washed with alcohol, are dipped or painted with shellac; fragile pieces are sprayed with the same varnish thinned with alcohol. After drying, a second coating of commercial electrotypers' varnish is applied. When this application has dried so that the article may be handled, dust on finely ground graphite or plumbago, smoothing it over the surface with a soft hair brush. Take care to brush the graphite evenly over every section to be plated, remembering that the metal deposits only where the surface has been prepared to carry electricity. Copper is undoubtedly the best metal to use for quick deposition and the prepared article should accordingly be hung in an acid copper solution. The deposit does not form at once on all sections of the surface but gradually works out from one or two points. When the desired thickness of copper is deposited, the work may be re-cleaned and transferred to another tank for the final deposit of the desired metal.

There are many other methods of preparing nonmetallic surfaces for plating work. In general, however, the brief directions just given are sufficient for the average work. For further discussion of the subject the reader is referred to works on electrotyping.

BRIGHT DIPPING

The foregoing discussion has considered the various methods of preparing work for the electroplating bath. But not all metals require plating, particularly brass and other copper alloys. They require only a refurbishing. It is, therefore, important to understand the art of removing from such work the oil remaining from machining operations, or the tarnish resulting from exposure. After the correct finish is received, through the action of acid dips, if a lacquer coating is added the original bright finish is preserved for some time.

One of the quickest methods of removing tarnish, or discoloration from metals, particularly copper alloys, is to immerse the stained piece in a strong acid solution. This process is known as bright dipping. There is little difference between the cleaning action of dips and pickles; the first is a rapid treatment while the latter is a prolonged operation. The instantaneous acid action is used with greatest success when the surface to be cleaned is smooth.

In general, the fastest acting dips are composed of nitric acid or sulphuric acid, alone or combined in varying proportions. For copper alloy articles, a dip of two parts sulphuric acid, one part nitric acid, and a sparse handful of common table salt for each five gallons of solution, gives a bright clean surface. For pieces that have been plated, and from which light discolorations must be removed before lacquering, a small quantity of water should be added to the solution. A soft, satin finish will be the result of using a dip of equal parts sulphuric and nitric acid in which has been dissolved one pound of metallic zinc for each five gallons of solution. For steel and iron, a favorite dip is prepared from equal parts of water and hydrochloric acid.

Acid dips should be prepared and used in stoneware jars placed in a tank of hot water. A dipping tank equipped with an exhaust hood is necessary since the acid fumes are quite poisonous. The construction of such a tank was described in a previous chapter.

When water is used, or two or more acids are mixed together, it is safest to combine them in relation to their weights, the heavier added to the lighter. Thus, if the mixture desired is composed of water and hydrochloric acid, the latter should be added to the former. Or if the solution is to be sulphuric and nitric acid, sulphuric acid, being the heavier, should be poured into the nitric acid. When zinc is employed to dull the finish, it should be dissolved first in the nitric acid, when it may then be added to the solution. Under no circumstances should acids be poured or mixed rapidly; such hasty action is dangerous.

Small pieces to be bright dipped are strung on wires, or placed in stoneware or wire baskets, while the larger work is handled separately on wire hooks. After a short immersion in boiling lye, the work is passed through hot water, then immersed in the acid dip for a few seconds. Upon removal, a thorough rinsing in hot water is given. Hot sawdust, blowing by compressed air, or oven drying must be used to prevent tarnishing.

CHAPTER VIII

PLATING SOLUTIONS AND THE ELECTRO-DEPOSITION OF METALS

Brass — Brass Plating Solution — Brass Anodes — Voltage Regulation for Brass Plating—Brass Coloring—Bronze—Bronze Plating Solution—Brass Anodes—Voltage Regulation for Bronze Plating — Copper — Copper Plating Solutions for Still Tank — Catalytic Agents — Copper Anodes—Voltage Regulation for Copper Plating—Copper Deposition—Copper Striking—Copper Coloring—Gold—Gold Plating Solution—Gold Anodes—Voltage Regulations for Gold Plating—Gold Deposition—Stop-Off Varnish—Iron—Iron Plating Solution—Iron Anodes—Voltage Regulation for Iron Plating—Lead—Lead Plating Solution—Lead Anodes—Voltage Regulation for Lead Plating—Nickel—Solutions for Still Tank Nickel Plating—Solution for Barrel Nickel Plating—Black Nickeling — Nickel Anodes — Voltage Regulation for Nickel Plating — Preparation of Work for Nickel Plating — Nickel Deposition—Silver—Silver Plating Solution—Silver Anodes—Voltage Regulation for Silver Plating—Silver Deposition—Silver Coloring—Tin—Tin Plating Solution — Tin Anodes — Voltage Regulation for Tin Plating—Tin Deposition—Zinc—Electro-Galvanizing—Solutions for Still Tank Zinc Plating—Solution for Barrel Zinc Plating—Zinc Anodes—Voltage Regulation for Zinc Plating — Zinc Deposition — Mechanical Machinery for Electro-Galvanizing.

It is difficult to determine the order in which the various metals used in electro-deposition should be considered. Nickel and brass plating are of most interest, perhaps, to those handling hardware and similar articles. Again, zinc deposition appeals to the operator in charge of the plating division of a factory whose output must be coated with a cheap protective metal to afford freedom from rust rather than to add to its appearance. On the other hand, gold and silver deposition, especially the latter, is of great importance to the manufacturer of jewelry, cutlery, tableware, and similar goods requiring a beautiful polished surface. For convenience, then, rather than for their degree of importance, the several metals will be considered in alphabetical order.

BRASS

Commercially, brass is one of the important metals; it is undoubtedly the most extensively used of all alloys. Its color, yellow, varies in shade according to the percentage of zinc and copper in its composition; an increase in zinc with a corresponding decrease in copper produces a lighter color, and vice versa. In practice, the proportion of each metal content approximates: copper, 60 per cent, zinc 40 per cent. Brass presents a more pleasing appearance than zinc, but is higher in cost. On the other hand, it is less expensive than copper and is not quite so susceptible to tarnish. It is, therefore, an excellent protective metal for deposit on iron products, to preserve the latter from the action of the atmosphere.

BRASS PLATING SOLUTION

A solution prepared from the following formula gives excellent results in brass plating:

Water	1 gal.
Sodium cyanide	9 oz.
Copper cyanide	5 oz.
Zinc cyanide	2 oz.
Sodium carbonate	4 oz.
Ammonium chloride	1/3 oz.

The addition of a very small amount of arsenic trioxide (white arsenic), dissolved in caustic soda, improves the appearance of the deposit. Ammonia also appears to assist in creating a fine grained deposit and may be added to the solution if desired.

The sodium cyanide is dissolved in the water and the resulting solution poured into two containers, half in each. In one container the copper cyanide is dissolved; to the other the zinc cyanide is added. The first solution is then put into the plating tank and the other poured in slowly. Before adding all of the zinc cyanide solution, a test should be made to determine the color of the deposit. If the plated article appears too dark in color, more zinc cyanide solution is added until the desired color is obtained. The remaining ingredients are then placed in the electrolyte in agreement with the formula.

A cyanide electrolyte for brass plating yields the best results. Experience shows that for this copper alloy, acid solutions are impractical. The cyanide bath may be used for either still tank or barrel plating.

BRASS ANODES

As stated in Chapter VI, the anodes may be either in the form of castings or rolled plates. While the casting type is more soluble, many platers prefer the rolled anode. Often copper and zinc anodes are used in alternate positions.

VOLTAGE REGULATION

For still tank brass plating the voltage may vary from four to six. For barrel work a slightly higher pressure may be required to produce the desired deposition.

BRASS COLORING

While a copper surface gives the greatest opportunity for successful coloring, many beautiful effects may be secured on brass-plated or solid brass articles. There are several available coloring solutions, among which are the following:

FOR BLACK COLOR

Ammonia	1 gal.
Copper carbonate	14 oz.
Sodium carbonate	8 oz.

The copper carbonate is dissolved in the ammonia. The sodium carbonate cannot be added directly, but should be first dissolved in a very small quantity of hot water. The article to be colored is dipped in this solution until the desired shade is obtained, when it is removed and rinsed in fresh water. Boiling for a short period in a caustic potash solution fixes the color. It is then washed thoroughly, dried, lightly scratch-brushed, and lacquered.

FOR BROWN COLOR

Water	1 gal.
Caustic soda	3½ oz.
Antimony sulphide	½ oz.

The caustic soda is dissolved in hot water after which the antimony sulphide is added. This is a very fast solution, only a few seconds being required to turn the brass a dark brown.

BRONZE

A copper alloy, which is much more durable than brass, but which is employed to less extent commercially, is bronze. This alloy is a composition of copper and tin, in proportion of 85 per cent to 90 per cent of the former to 15 per cent to 10 per cent of the latter. Because of the large copper content, bronze is quite expensive, and is, therefore, not used where brass may be substituted. For electroplating work, however, bronze may often be employed to advantage.

BRONZE PLATING SOLUTION

A good bronzing solution may be prepared from the following formula:

Water	1 gal.
Sodium cyanide	6 oz.
Sodium bisulphate	2 oz.
Copper cyanide	4 oz.
Tin chloride	½ oz.

In a manner similar to the preparation of the brass electrolyte, dissolve the sodium cyanide in the prescribed quantity of water. This solution is then divided between two containers. Into one is poured the tin chloride; to the remaining solution is added the copper cyanide and sodium bisulphate. The tin chloride solution is added to the copper bath until the desired color is obtained.

BRONZE ANODES

Either cast or rolled anodes are available for bronze plating. The cast type is usually preferred. The anode area should exceed the surface to be plated.

VOLTAGE REGULATION

A lower voltage may be used for bronze plating than is required for brass work. In most cases a pressure of two to four volts is sufficient to obtain the desired current density.

COPPER

Copper fills an important place in the world's industries, especially those relating to the production and maintenance of electrical machinery. It is a very malleable metal of a reddish color. As has been previously indicated, copper enters into the composition of many of the familiar alloys, such as bronze, brass, gun metal, german silver, bell metal, and aluminum bronze. The art of copper plating has advanced to a great degree in recent years, especially in the preparation of electrotype plates. A copper coating is also quite often deposited on baser metals as a foundation for other metals, such as nickel and silver.

COPPER PLATING SOLUTIONS FOR STILL TANK

There are two divisions of copper plating electrolytes: alkaline and acid. The former finds the greater use, although more difficult of management than the acid bath. Such metals as iron, tin, and zinc are electro-positive with respect to copper, and an acid solution cannot be used in the deposition of copper upon them. On the other hand, the acid bath is invariably used for the plating of brass and other metals less positive than copper, as well as for electrotyping.

An alkaline formula which yields a solution producing a fine grained deposit of copper is:

Water	1 gal.
Sodium cyanide	3½ oz.
Copper cyanide	3 oz.
Sodium carbonate	2 oz.
Sodium hyposulphite	¼ oz.

The plating tank should be filled about one-third full of hot water. The other ingredients should be added and dissolved in the following order: sodium cyanide, copper cyanide, sodium carbonate, and sodium hyposulphite. Finally, enough water should be poured in to fill the tank to the desired level. It is usually best to wait a short time for the solution to clear before starting the plating operation.

A very simple acid-copper plating bath may be compounded as follows:

Water	1 gal.
Copper sulphate	5 oz.
Sulphuric acid	1 oz.

The quantity of any of the three may be varied to a slight degree to obtain the desired results.

CATALYTIC AGENTS

It is difficult to determine why certain substances when added to electrolytic solutions tend to increase the current density and to produce a smooth fine-grained deposit. Experience shows the very interesting fact that the addition of glue, gelatine, glucose, or grape sugar in small quantities to the plating bath produces very desirable working conditions. The United States Bureau of Standards is carrying on extensive experiments of this nature. It is reported that one part of glue in ten thousand parts of solution produces a noticeable effect. It is, therefore, suggested that minute quantities of any of the mentioned or similar catalytic agents be added to the acid bath.

COPPER ANODES

Anodes for use in copper plating may be in plate form. Often sheets of copper, cut to suitable size, will suffice. One difficulty met with, especially when cyanide solutions are used, is the coating of the anode surface with a substance which is a non-conductor of electricity. This condition necessitates frequent removal of the plates for cleaning.

VOLTAGE REGULATION

For still tank deposition the plating voltage may vary from two to four for the cyanide bath and from ½ to 1½ for the acid electrolyte. In barrel plating the current pressure required is often as high as ten volts for alkaline solutions, although it may be less for acid baths.

COPPER DEPOSITION

While there is ordinarily nothing difficult about copper plating, under certain conditions special care must be exercised. It is suggested, for instance, that sand blasting be employed in the preparatory cleaning process instead of pickling. Unless such precautions are taken in the cleaning of castings, for example, weak spots may appear in the coating. For such work no advantage is gained, if the first deposition was in an alkaline bath, by completing the plating operation in an acid solution, although this is the usual procedure for articles leaving the cyanide electrolyte in perfect condition. Furthermore, a good durable coating of copper must always be deposited on iron, tin, and zinc articles in an alkaline bath before transferring them to the acid solution where a heavy deposit can then be built up quickly.

COPPER STRIKING

A quick and positive method of cleaning work for the plating process is copper ''striking'' or ''flashing.'' This was described in Chapter VII. Not only does the gas thrown off at the surface of the article clean the piece, but a light film of copper is deposited forming a perfect foundation for the deposition of any metal. The tank is of iron and forms the positive or anode plate. The article is connected to the negative bus bar of the supply circuit. The solution used for this process is:

Water	1 gal.
Sodium cyanide	1½ oz.
Copper cyanide	½ oz.
Caustic soda	8 oz.

The sodium cyanide is dissolved in the water, after which the copper cyanide and caustic soda are added.

This solution is worked at a high current density with a voltage of about ten. A fine film of copper will be deposited in but fifteen to twenty seconds.

COPPER COLORING

Many pleasing and artistic effects may be secured by coloring copper-plated surfaces with various chemicals. The article to be colored is cleaned in the usual manner, immersed for a few moments in a muriatic-acid dip, and copper plated. Upon coming from the plating bath, it is rinsed thoroughly and suspended in the coloring solution for a length of time dependent upon the shade desired. When removed from this solution the work is carefully rinsed in clean water and lightly scratch-brushed. For hardware and office fixtures the appearance is often improved by ''spotting'' in several places with cloth or felt ''buffs.'' The finished surface may then be preserved with lacquer.

A coloring solution producing a dark bronze effect is composed of:

Water	1 gal.
Potassium sulphate	8 oz.

A smaller quantity of potassium sulphide may be used or ammonium sulphide may be substituted for the potassium sulphate.

Green colors on copper may be secured by painting the work with a solution composed of:

Vinegar	1 quart
Copper carbonate	16 oz.
Ammonium chloride	8 oz.
Cream of Tartar	4 oz.

Unlike the treatment with other solutions, this work is not rinsed after immersion or painting. The liquid is allowed to dry on the article as slowly as possible; thus giving the chemicals an opportunity to act upon the copper. After the desired finish is secured, the surface is brushed lightly with softened bee's wax.

GOLD

Gold is a malleable yellow metal. Due to its chemical inactivity, it is able to resist decomposition by the atmosphere and most acids. It is employed to a great extent in the arts, but is not used in the pure condition on account of its softness. The chief alloy of gold is copper, the latter imparting a reddish color as well as increasing its hardness. The composition of gold usually employed in jewelry is measured in carats, twenty-four carats being the pure metal. Several of these alloy combinations are: 20-carat gold, equivalent to 20 parts of gold to 4 of copper; 18-carat gold, equivalent to 18 parts of gold to six of copper. The total number of parts, as may be seen, is always twenty-four.

GOLD PLATING SOLUTION

A good gold solution may be composed of:

Water	1 gal.
Gold chloride	3 oz.
Potassium cyanide	10 oz.

The potassium cyanide is dissolved in warm distilled or rain water. To this solution is added the gold chloride. The quantity of potassium cyanide may need to be varied to secure the desired color.

GOLD ANODES

While a strip of platinum may be used as an anode, the metal contents in the solution being replenished by the addition of gold chloride, it is better to employ a thin sheet of pure gold.

VOLTAGE REGULATION

A current pressure, varying from ½ to 4 volts, is required for gold plating. Experience with a particular solution will soon show the exact voltage necessary for the desired color and speed of deposition.

GOLD DEPOSITION

It is best to work the plating solution at a temperature of about 125° F. A faint film of gold is first deposited and the article lightly scratch-brushed, to lay down the grain. The work is then thoroughly washed in hot water, dipped in cold water, and immersed again in the plating solution for the final coating. It is a good plan to keep the work in motion by swinging it slightly on its slinging wire.

When it is necessary to gold plate or gild the inside of hollow vessels, the following method may be employed. The vessel is filled with the gold solution to the level desired and connected to the negative terminal of the current supply. An anode of gold is then lowered into the solution, care being taken to see that the copper connecting wire is not also immersed.

The deposition is continued in a manner identical with the method used for still-tank plating.

The finish of the completed coating may, in some degree, be governed by the condition of the surface prior to deposition. Frosted or satin finishes are thus the direct result of sand-blasted or scratch-brushed surfaces. The sand blast should be operated at a low air pressure (about five pounds per square inch), and if possible, a fine grade of pumice should be used instead of the regular sand.

In the matter of the color of the deposit gold is very sensitive to changes in the current density, the temperature of the bath, and the composition of the plating solution. Many beautiful tints, such as rose, red, green, and the like may be secured by using special solutions. Such solutions are available on the market and since the directions for their use are peculiar to each, and are furnished by the manufacturer, they need not be discussed here.

STOP OFF VARNISH

When several colors of metal are desired on one article, special measures must be taken. The lightest shade desired is first deposited over the entire piece. After washing and drying, those sections which are to remain the light color are covered by painting with a "stop off" varnish. A soft camel's-hair brush should be used for this work. As soon as the varnish is dry the article is washed, dipped in a warm caustic potash solution to remove any existing stains, rinsed, and placed in the solution prepared to give the other color desired. After gilding, the varnish is removed by dissolving with turpentine or benzine applied with a soft brush. The "stop off" varnish may be purchased in the grade required for any specific work.

IRON

Iron is a hard, gray-white metal which is seldom available in a pure state. Steel is produced from iron by a special process. Both of these metals are of the greatest importance in the industrial world. While the electroplater deposits other metals upon steel and iron objects, he has practically no demand for iron-plated articles. For this reason but little space will be given here to the deposition of iron.

IRON PLATING SOLUTION

A formula which resembles that to be suggested later for nickel plating may be made up as follows:

Water	1 gal.
Ferrous ammonium sulphate	14 oz.

The ferrous ammonium sulphate is dissolved in hot water. The solution should be neutral or very slightly acid.

IRON ANODES

The anode surface should be in excess of the area to be plated. Absolutely pure iron is difficult to obtain, but the purest available should always be used. If the anodes show a tendency to become covered with a black substance, they should be removed and thoroughly cleaned.

VOLTAGE REGULATION

Because of the ease with which hydrogen is liberated in iron solutions, the current density should be quite low. Less than one volt current pressure is sufficient for most solutions. Since iron deposition is quite similar in many respects to the more commonly-known nickel plating, it is suggested that the discussion of the latter be read before considering the former.

LEAD

Lead is a soft bluish-gray metal which melts at the comparatively low temperature of 617° F. Unless exposed to the atmosphere, lead shows a high luster. Until recently, the electroplater was little interested in the deposition of lead. At present, however, metal containers are frequently required to be lead-lined; this is easily accomplished by filling the vessel with the correct electrolyte, immersing lead anodes connected to the positive supply circuit, and using the container as a cathode.

LEAD PLATING SOLUTION

An excellent electrolytic solution for the deposition of lead is prepared in the following manner:

Water	1 gal.
Hydrofluoric acid	32 oz.
Boric acid	12 oz.
White lead (lead carbonate)	16 oz.

The hydrofluoric acid is placed in a wood container. The boric acid is then added slowly. This operation should be performed in the open or under a ventilating hood since the fumes should not be inhaled. As soon as the boric acid is dissolved, the white lead may be added, followed by the required quantity of water.

As explained in the discussion of copper plating, the addition of very small quantities of glue tends to improve the character of the deposit. And this is especially true in lead plating.

LEAD ANODES

Only anodes of pure lead should be used for deposition. They can be used in the form of castings, but lead plates or sheets are more often employed.

VOLTAGE REGULATION

As stated in a previous chapter, solution agitation allows a greater current density. The most simple method of agitation is the release of compressed air from a tube in the bottom of the tank. Experience indicates that such agitation is of little help in lead plating, yet any form of mechanical agitation somewhat improves the texture of the deposit. Heating the solution produces the same results. Again, a more concentrated solution gives a fine-grained deposit since it allows greater current density. Under normal conditions, however, the voltage required is six, provided there is solution agitation.

NICKEL

Nickel is a hard, brittle, white metal. Because it is capable of taking a high polish, it is extensively used in electroplating for deposition on the baser metals. Again, it is not easily corroded by the atmosphere and is, therefore, a valuable protective metal for iron articles.

SOLUTIONS FOR STILL TANK PLATING

A solution for nickel plating may be compounded as follows:

Water	1 gal.
Nickel ammonium sulphate (Double salt)	12 oz.
Nickel sulphate (Single salt)	2 oz.
Boric acid	2 oz.
Ammonium chloride	1 oz.

The double nickel salt is dissolved in hot water. To this solution is added the single nickel salt and ammonium chloride. The boric acid is dissolved separately in hot water before it is mixed with the solution previously prepared.

A more generally known, and certainly more simple, nickel-plating bath may be formed from:

Water	1 gal.
Nickel ammonium sulphate (Double salt)	14 oz.
Boric acid	2 oz.

The nickel ammonium sulphate is dissolved in hot water, then a quantity of the latter is added to the solution until a hydrometer reading shows a density of about 7° Baumé. (1.05 sp.g.)

SOLUTION FOR BARREL NICKEL PLATING

For barrel nickel plating, a slightly different solution is suggested. Such an electrolyte is made up as follows:

Water	1 gal.
Nickel sulphate (Single salt)	12 oz.
Boric acid	4 oz.
Ammonium chloride	2 oz.
Muriatic acid	½ oz.

To the water is added the single nickel salt and the ammonium chloride. The boric acid is dissolved separately in a small quantity of hot water and then added to the general solution with the muriatic acid.

BLACK NICKELING

A solution quite similar to that used in bright nickel plating, yet which produces a dead-black deposit, is composed of:

Water	10 gal.
Nickel ammonium sulphate (Double salt)	5 pounds
Sulpho-cyanide of soda	1½ pounds
Sal ammoniac	1½ pounds
Zinc sulphate	1 pound
Sodium carbonate	4 oz.

The double-nickel salt is dissolved in the water. The others are then added in the following order: Sal ammoniac (Ammonium chloride), zinc sulphate, sodium carbonate, and finally, sulpho-cyanide of soda.

NICKEL ANODES

Nickel anodes, 99 per cent pure, may be secured commercially. Nothing is quite so important in nickel plating as pure nickel anodes, since even traces of other metals, particularly copper, tend to discolor the deposit. Anodes are available in either cast or rolled form. The great advantage of the cast anode is its porous composition, which makes it readily soluble. When rolled anodes are employed, their hardness prevents their going into solution to such an extent that the electrolyte is weakened and additional nickel salts must be added to maintain the required strength.

VOLTAGE REGULATION

Nickel plating solutions offer considerable resistance to the passage of an electric current and for this reason a voltage of 2½ to 5 is often required for still-tank work. A rough, crystalline deposit is the result of a heavy current.

Barrel nickel plating requires a current pressure of about 10 volts. Because of the constant solution agitation, a high-current density is permissible.

The current pressure necessary for black-nickel plating is quite low, ½ volt being sufficient to produce the best results.

PREPARATION OF WORK FOR NICKEL PLATING

The preparation of work for plating was discussed to some extent in Chapter VIII. A few brief remarks on the preparation of articles to be nickel-plated might nevertheless, be added at this time. There are two essential requirements: A smooth, polished surface, and a preliminary coating of some metal less positive than nickel. A deposited nickel coating is very hard. For this reason it is desirable to eliminate the need of as much polishing work as possible. A preliminary surface that has been polished until it is smooth as the desired finish of the completed coating, will assist greatly in producing a perfect deposit. Moreover, such careful preparation of the surface permits the elimination of pickling and acid-dipping operations which later appear to have a detrimental effect on the nickel deposit. While it is possible to deposit nickel directly upon iron, steel, zinc, tin and other metals more electro-positive in nature to nickel, better results are obtained by first giving articles of those metals a light coating of copper or brass. In many instances, "striking" in the copper bath described in this chapter, is sufficient

NICKEL DEPOSITION

More than usual care is necessary in the management of nickel solutions. In general, there are five items which influence the character of the deposit. They are: cleanness, metal content of solution, acidity of solution, temperature of solution, and current strength.

Cleanness is required in any branch of electroplating, but in nickel deposition it is absolutely essential. Unless precautions are taken, dust that has settled on the surface of the solution will adhere to the work as it is immersed. Obviously, there will be an inferior deposit at the points covered by the dust and the finished surface will show small "pin holes." Again it must be remembered that because of its neutral reaction, the nickel solution does not have the chemical strength to dissolve light films of oil or grease, which cyanide or acid electrolytes of other metals do to some extent. Thus, even the touch of a finger renders the work unclean for the nickel-plating bath. Hence, the necessity for special care in the scouring and preliminary cleaning process. To insure rapid drying after cleaning, the work is placed in special machines, as shown in Figs. 105 and 106.

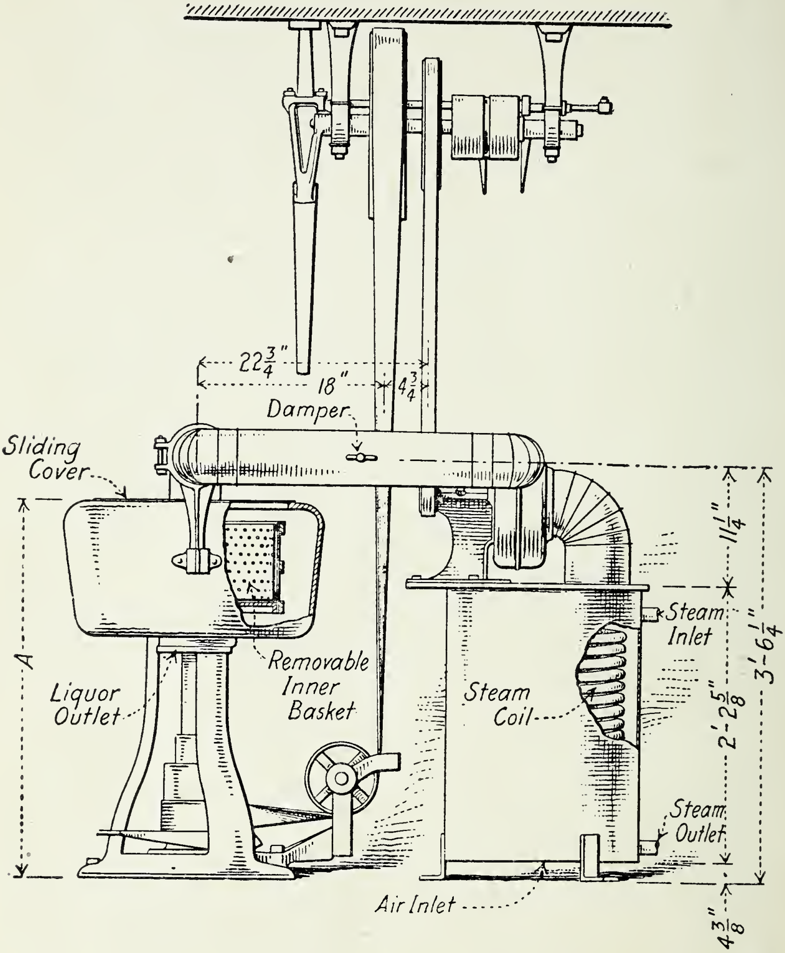


Fig. 105.—Metal Drying Apparatus. Work Taken From the Plating Tank is Rinsed in Fresh Water and Placed in This Machine for Quick Drying

(General Platers' Supply Co.)

The hydrometer is a valuable aid in determining the content of the nickel-plating bath. A reading of 6° to 8° Baumé indicates that the metal content is sufficient. Any reading below 5° denotes a weak solution and more single nickel salts should be added. This weak condition is usually the result of the use of rolled anodes or insufficient active anode surface.

Success in nickel plating requires that the solution be very slightly acid. One of the chief causes of "peeling" or "blistering", however, is an excess of acid, so care must be taken to see that only the necessary quantity of acid is used to bring about the desired reaction. A bath showing an alkaline reaction produces discolored, dark work. Litmus paper, which was described in Chapter VI, has the property of turning red when dipped in an acid solution, and blue when exposed to an alkaline bath. Although the double nickel salt in solution is usually neutral, a few drops of sulphuric acid may be added until the solution shows a slight acid reaction, when tested with litmus paper. Should it appear that the electrolyte is too strongly acid, then more neutral salts are added until the correct reaction is obtained.

A subject that receives but little attention, yet which has as much, if not more, to do with success or failure in nickel plating than any other one condition, is the temperature of the solution. A temperature below 50° F. is apt to cause crystallization of the salts. Usually a certain quantity of hydrogen is liberated at the cathode; the temperature must be regulated for each solution so that the quantity of these gas bubbles is not excessive and thus cause the metal to "pit." If the plating tanks are equipped with steam-heating coils, similar to those described in

Chapter V, the temperature may be regulated with little difficulty.

A very strong current also causes excessive liberation of hydrogen which, as has already been stated, is one of the chief causes of "pitted" and uneven deposits. Only experience with each particular solution will show the current density required for successful work.

Reference was made earlier in the chapter to the use of certain catalytic agents. Glue cannot be used in nickel-plating solutions, since it causes a brittle deposit which flakes off readily. Glucose, however, has no such detrimental effect but rather produces a smooth fine-grained deposit.

SILVER

Silver is a white metal, having a high lustre. It is malleable and can therefore be rolled or beaten into very thin sheets. It is a harder metal than gold, but softer than copper. While it is not acted upon by the air or water, it combines with sulphur to form black silver sulphide. Thus the surface of silver-plated articles, exposed to smoke or gas containing traces of sulphur, is tarnished with the black sulphide. Silver presents the least resistance, of all metals, to the flow of electricity.

SILVER PLATING SOLUTIONS

A simple formula for a silver plating solution is prepared as follows:

Water	1 gal.
Silver chloride	3 oz.
Sodium cyanide	8 oz.

The sodium cyanide is dissolved in warm water. To this solution is added the silver chloride which has been reduced to a paste with water. Another quite similar formula substitutes potassium cyanide for the sodium cyanide. It may be necessary to add more cyanide to secure the proper working conditions of the bath. It is well, though, to use the cyanide with discretion; an excess will discolor the deposit as well as make the plating process sluggish.

SILVER ANODES

Rolled anodes of fine silver are usually employed. The purity of the metal influences the deposit and only the purest silver should therefore be used for anodes. While it is not absolutely essential, the anode will pass into solution with greater ease if it be annealed prior to placing in the bath.

VOLTAGE REGULATION

The required current pressure is exceedingly low for silver plating, but ½ to 1 volt being sufficient. The average current density is approximately 2½ amperes per square foot of surface plated.

SILVER DEPOSITION

The work to be silver plated is cleaned in the usual manner so that all grease, oxides and other tarnish are removed. For iron and steel articles, a copper film may be deposited to form a foundation for the silver. More often, however, a silver "strike" is used. The work is dipped for a moment in a hot potash bath and then transferred, without rinsing, to the "strike" solution. This bath is usually similar to those described in the paragraph on silver plating solutions, with the possible exception that there may be an excess of cyanide and a decrease in the metal content. A very strong current is used with the result that a thin adhesive film of silver is quickly deposited. The work may then be lightly scratch-brushed, rinsed and immersed in the regular vat for the completion of the deposition process. Tin, zinc, and their alloys may also receive the foregoing preliminary treatment before entering the plating tank. Copper and metals containing a large percentage of copper are sometimes prepared by dipping in a solution of potassium cyanide to which a small quantity of mercuric oxide has been added. The article, chemically cleaned in an acid dip, is immersed for a few moments in this solution. Upon removal it will be seen that a thin coating of mercury has adhered to the surface. The article, thus treated, is suspended in the standard solution for the silver plate.

SILVER COLORING

It is sometimes desired to color silver-coated articles. Silver surfaces which have been colored a blue-black may be "spotted" on a soft cloth wheel to obtain varying shades, or the embossed portions may be brightened, leaving the background the original color. The following is the usual so-called "oxidizing" solution for silver coloring:

Water	1 gal.
Ammonium carbonate	2 oz.
Potassium sulphide	1 oz.

If a hot solution is employed, only a few seconds are required to color the silver.

TIN

Tin is a soft, malleable, white metal. Its chief uses, commercially, are in the formation of alloys and as a protective coating for vessels. While tin plating is not extensively employed in the industrial world, yet, under certain conditions, tin deposition is quite essential. Usually, however, the coating is secured at less cost by merely dipping the article in molten tin.

TIN-PLATING SOLUTIONS

A satisfactory tin-plating solution is made up of:

Water	1 gal.
Caustic soda	16 oz.
Sodium hyposulphite	8 oz.
Tin chloride	4 oz.
Sodium cyanide	2 oz.

The water is placed in three containers, an equal amount in each. The caustic soda is dissolved in the first; the sodium hyposulphite in the second; the sodium cyanide in the third. A little water is added to the tin chloride and then worked into the consistency of paste. The caustic soda and sodium hyposulphite solutions are poured together. To this mixture the tin chloride is added followed by the sodium cyanide solution. A very small quantity of glue should also be used if a fine close-grained deposit is desired.

TIN ANODES

Cast anodes are usually employed for tin plating, although other types can be used with success.

VOLTAGE REGULATION

There may be a wide variation in the current pressure, the best results being obtained with voltages ranging from two to six.

TIN DEPOSITION

Little difficulty is experienced in the management of tin-plating solutions. The preparatory cleaning solutions are identical with those described in Chapter VII. If glue, or any of the other catalytic agents previously mentioned, is added to the solution, even heavy deposits may be secured without trouble.

ZINC

Zinc is a bluish-white metal which at ordinary temperatures is quite brittle. When heated to 212° F, it becomes malleable as well as ductile and may be rolled into sheets. Above 424° F., however, it becomes brittle again, and finally melts at about 775° F. In this zinc is peculiar.

ELECTRO-GALVANIZING

Zinc is widely employed as a protective coating for such metals as are affected by the atmosphere. Until recently, a process known as hot galvanizing was employed in all instances where this film of zinc was required. As the term implies, this method required the immersion of the work in molten zinc, which had a deleterious effect on those metals whose characteristics were changed by an increase in temperature. Of late, however, much progress has been made in the electro-deposition of zinc, often termed ‘‘cold galvanizing'' or '' electro-galvanizing''. Because zinc is electro-positive to iron and steel it is especially valuable as a protective coating for these metals. Unlike hot galvanizing, the electro-deposited coating of zinc may be varied in thickness and is certainly smoother and more durable.

SOLUTIONS FOR STILL TANK ZINC PLATING

As is the case with copper, there are two kinds of zinc-plating solutions available for still-tank work: acid and alkaline. An acid solution which has met with favor is composed of:

Water	1 gal.
Zinc sulphate	32 oz.
Aluminum sulphate	2 oz.
Ammonium chloride	2 oz.
Sulphuric acid	¼ oz.

The zinc sulphate and ammonium chloride are dissolved in part of the water while the aluminum sulphate is dissolved in the remainder. The two solutions are then mixed together and the specified quantity of sulphuric acid is added. Grape sugar may be used as a catalytic agent to prevent roughness in the deposit.

Another formula, quite similar to the above and which is prepared in the same manner, is:

Water	1 gal.
Zinc sulphate	32 oz.
Aluminum sulphate	4 oz.
Ammonium chloride	2 oz.
Boric acid	2 oz.

An alkaline or cyanide zinc solution does not deposit the metal as rapidly as the acid bath, but the coating is more uniform. A formula for such a solution is:

Water	1 gal.
Zinc cyanide	3 oz.
Sodium cyanide	3 oz.
Caustic soda	4 oz.
Aluminum sulphate	¼ oz.

The sodium cyanide and the zinc cyanide are dissolved in a portion of the water. The aluminum sulphide is dissolved in the remaining part in another container. The two solutions are then mixed together. When the tank has been filled to the proper depth, the caustic soda is added.

Another very good solution, which in composition and preparation is similar to the foregoing, is:

Water	1 gal.
Zinc cyanide	4 oz.
Sodium cyanide	4 oz.
Caustic soda	4 oz.
Ammonium chloride	2 oz.

Cyanide solutions usually work best when their temperatures are raised above 150° F.

SOLUTIONS FOR BARREL ZINC PLATING

Many small iron and steel articles may be quickly protected against rust by receiving a light coating of zinc in a plating barrel. Solutions for barrel plating vary but little from those required for still-tank work, but the following formula is recommended:

Water	1 gal.
Zinc sulphate	48 oz.
Aluminum sulphate	3 oz.
Ammonium chloride	3 oz.
Sulphuric acid	½ oz.

The chemicals are dissolved in water and the solutions combined in the same manner as specified for acid-zinc baths for still-tank plating.

There are a great number of formulæ for zinc plating, but those given here undoubtedly produce the best results with the least expense and effort.

ZINC ANODES

For zinc plating a cast anode is preferred. It may be round, flat, elliptical or corrugated in form. The purest metal obtainable should be used for the anodes if perfect deposits are to be expected. The anode surface should be at least one-third greater than the area to be plated.

VOLTAGE REGULATION

The current pressure for acid solutions for still-tank work may vary from 3 to 6 volts, while for cyanide solutions the pressure may range from 2 to 4 volts. Barrel plating always requires a much higher current pressure, and for zinc deposition should be 10 to 12 volts. Other types of mechanical plating also require a high-current pressure of 8 to 10 volts.

ZINC DEPOSITION

There is little to say as to special precautions to be taken in the management of galvanizing solutions.

If the work has been carefully cleaned no difficulty will be experienced in obtaining a perfect coating. The only possible exception to this statement is the handling of iron castings which, because of their porous nature, are difficult to clean. The best solution to the problem, in this instance, is to clean them electrically in an alkaline bath composed of equal parts of caustic soda, sodium cyanide, and sodium carbonate dissolved in water. The tank should be of steel since it composes the anode. The casting is connected to the negative line and acts as the cathode. A current pressure of 6 to 8 volts is sufficient to clean the

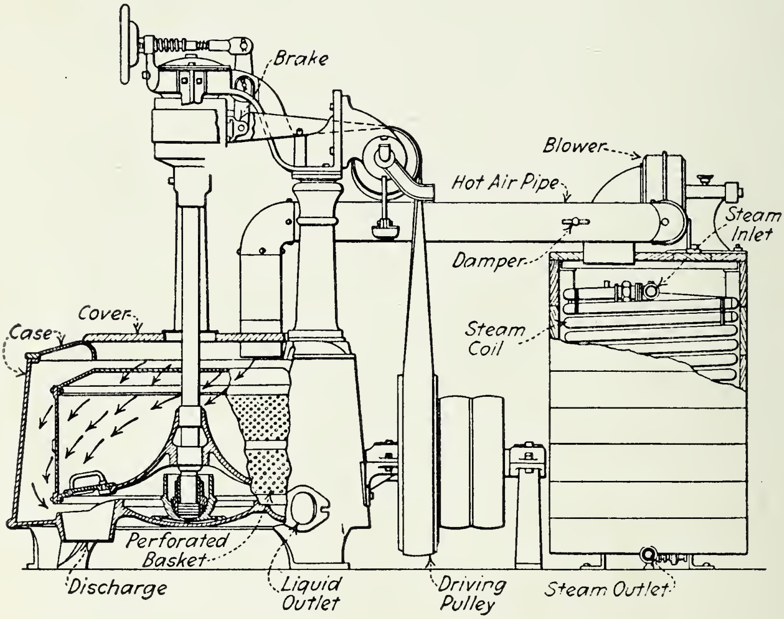


Fig. 106.—Metal Drying Apparatus Arranged with Bottom Discharge

(General Platers' Supply Co.)

work in a few minutes, provided the action of the gas thrown off at the surface of the casting appears vigorous. Sand blasting is also an excellent method of cleaning work for zinc plating, no chemical treatment being required after such an operation.

MECHANICAL MACHINERY FOR ELECTRO-GALVANIZING

While automatic machinery is employed in the deposition of many metals, the greatest number and variety is found in machines designed especially for electro-galvanizing. The subject of galvanizing is one so broad that it cannot be discussed in this volume. Merely casual observation of the iron and steel articles about us in our homes, in the industries, on the farms—shows that the majority are protected from rust and other corrosion by galvanizing. To compete with the low cost of hot galvanizing, automatic plating machinery must be used, thereby allowing quantity production. The commercial electroplater, who finds a demand for such work, will be wise to study the modern plating machinery to determine the extent to which such devices would increase the quality and quantity of his output.

CHAPTER IX

POLISHING, BUFFING AND LACQUERING

The Polishing Room—The Motor Driven Lathe—The Belt-Driven Lathe — Overhanging Lathes — Belt Strapping —Grinding Lathes—Surface Grinders—Portable Grinders—Dust Collector Hoods—Polishing—Polishing Wheels —Gluing the Wheels—Cleaning the Wheels—Emery Applications—The Glue Heater—Emery Trough—Buffing—Buffing Wheels—Buffing Compositions—Speed of Buffs—Scratch Brushes—Burnishing Barrel—Lacquering—The Lacquer Room—Lacquer Application—Colored Lacquer.

THE POLISHING ROOM

All grinding, polishing, and buffing operations, because of the abrasive dust thrown from the wheels, must be performed in a room isolated from the plating tanks. In arranging the floor plan, several important features must be considered. The polishing lathes, for instance, must be so situated that the operators face the light as they work, thereby eliminating conflicting shadows. On the other hand, sufficient space must be allowed between the lathes for the storage of work, thus making it possible to continue operations without moving from the wheel.

Besides the polishing and buffing machines, a well-equipped polishing room should be provided with a ball burnisher, tumbling barrels, and sand-blast apparatus. These latter two have already been described in some detail and, although they are part of the polishing-room equipment, will not require further consideration in this chapter.

Power for driving the machinery may be supplied by a motor of the correct capacity and speed. If the motor is located in the polishing room, dust-proof or protected bearings should be provided. It is seldom necessary to provide a motor for each machine; power may be transmitted to a number of machines through line shafts and counter shafts.

THE MOTOR-DRIVEN LATHE

The most simple type of polishing or buffing lathe is direct motor-driven, the armature shafts, extended beyond the bearings, serving as the arbor for the wheel. This extension may be made on either or both sides of the motor. Particular care must be exercised in the protection of the bearings and commutator against the injurious emery dust from the wheel. A fully-enclosed motor, as illustrated in Fig. 107, should be secured, if possible. It will be noted that even

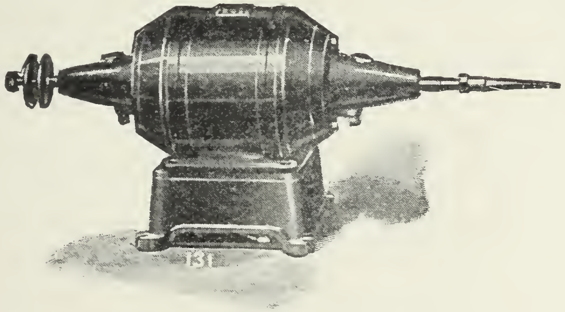


Fig. 107.—Polishing and Buffing Motor Lathe

(General Platers' Supply Co.)

the oil holes and cups are omitted, self-oiling bearings being used.

The advantage of this single unit machine is apparent. It may be placed where most convenient, on a bench or on a column, without regard to location of overhead shafting. Again, such units may be added to the equipment without causing a drain upon the existing power plant.

THE BELT-DRIVEN LATHE

Belt-driven lathe heads form the standard equipment for many polishing rooms. According to the shop requirements, they can be secured with flat, cone, or grooved pulleys. The bearings are dust-proof and are so constructed that adjustment for wear can be made when necessary. Ball bearings are

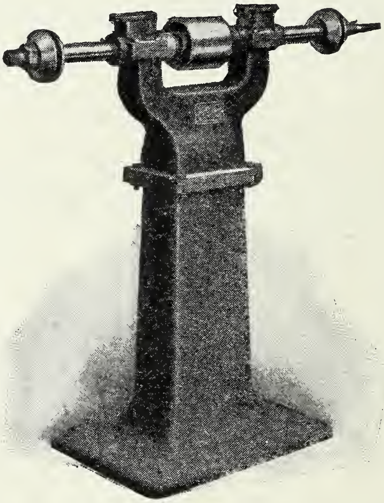


Fig. 108.—Polishing and Buffing Head on Column

(Bennett O'Connell Co.)

sometimes employed on the small machines. A column, upon which the lathe head can be mounted, can be used or the lathe can be secured to the work-

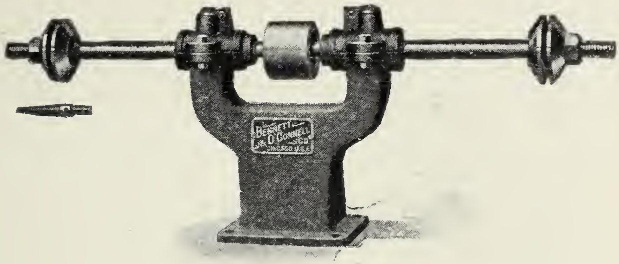


Fig. 109.—Polishing and Buffing Lathe

(Bennett O'Connell Co.)

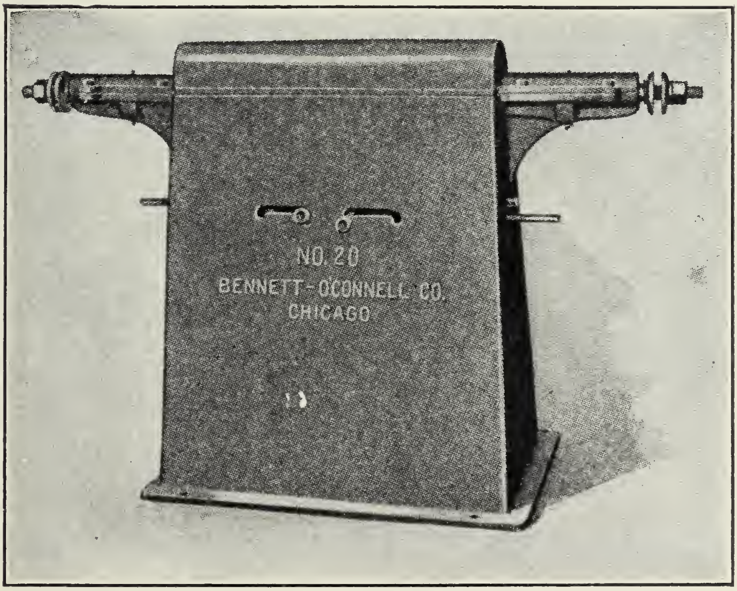


Fig. 110.—View of Lathe Arranged for Belting from Shaft Below the Floor

(Bennett O'Connell Co.)

table. The spindle ends are usually tapered with screw points, but a straight-threaded arbor may be provided if desired. The several illustrations show polishing and buffing lathes for both light and heavy

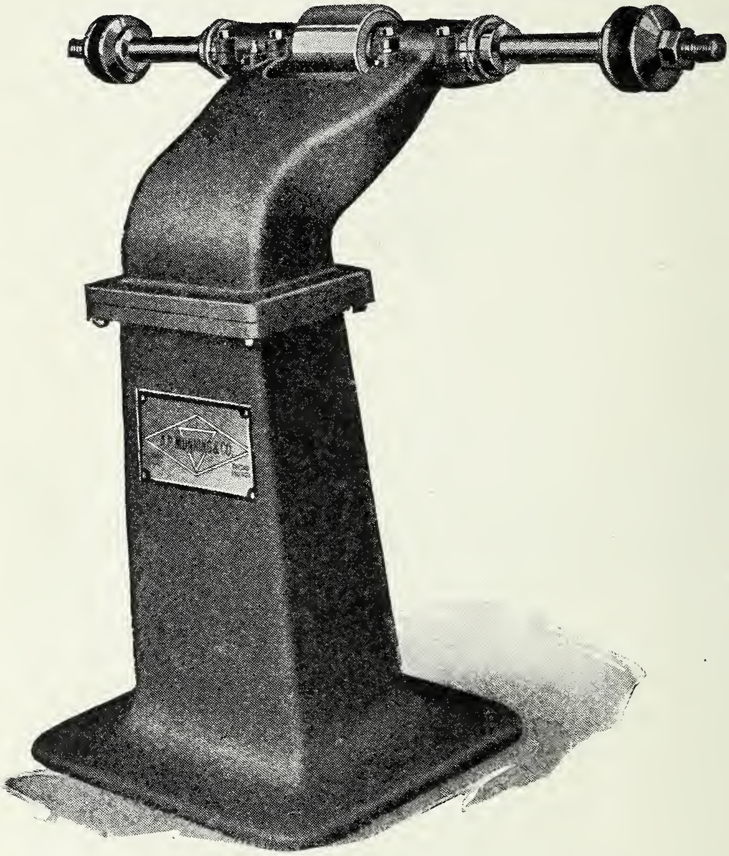


Fig. 111.—Overhanging Polishing Lathe
(A. P. Munning & Co.)

duty, that in Fig. 108 shows a polishing and buffing head mounted on a column. The simple lathe in Fig. 109 is a plain bearing form, and that in Fig. 110 is a heavier type adapted to be driven by belting from shafting placed below it.

OVERHANGING LATHES

An overhanging lathe, such as is shown in Fig. 111, is adapted to all classes of work. The overhang permits its use on large work of irregular shape, without interference with the column.

BELT STRAPPING

A belt-strapping attachment may be conveniently used in connection with a polishing head. For the wheel is substituted a flanged pulley. At a distance, depending upon the length of the belt, a second pulley support is secured to the floor. This support, as is clearly indicated in Fig. 112, may be adjusted to tighten or loosen the belt. There are many classes of work which can be polished with ease on this

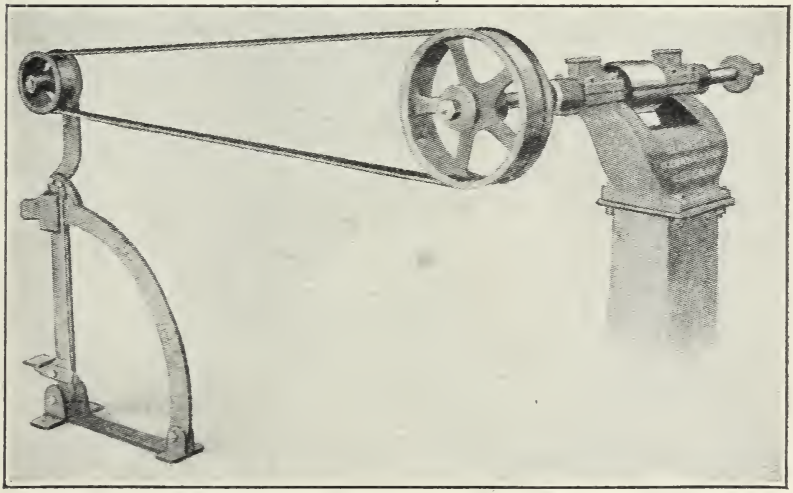


Fig. 112.—Belt Strapping Attachment

(Bennett O'Connell Co.)

device, which would be handled with difficulty on a wheel.

GRINDING LATHES

A grinding lathe is rigidly constructed, but in general appearance is similar to the standard polishing head. For convenience, a rest is provided as well as a container for water. It is quite important to place substantial guards around emery or composi-

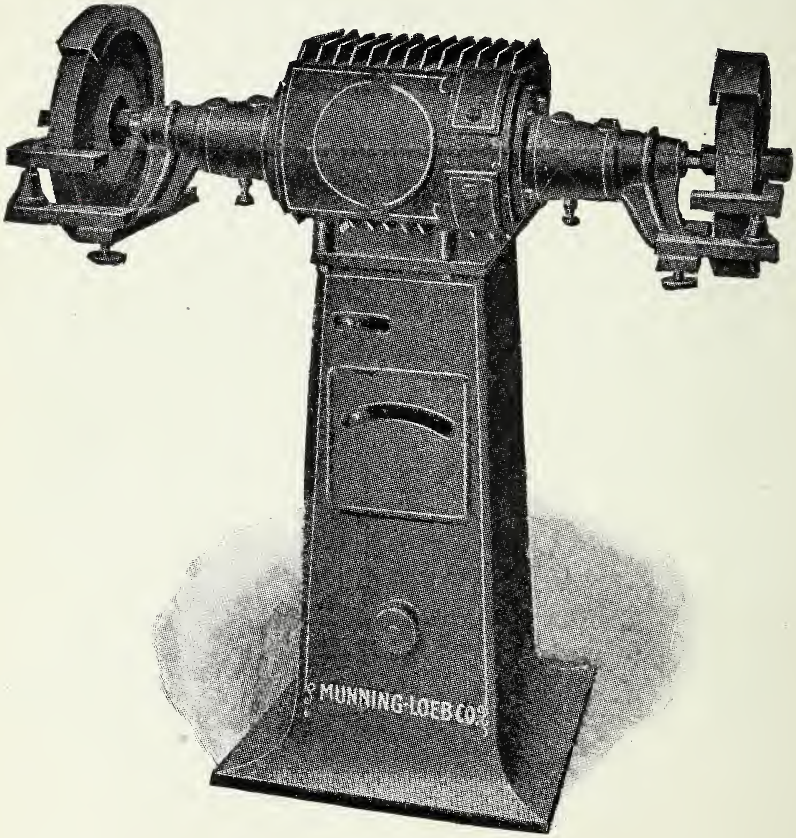


Fig. 113.—Motor Driven Grinder

(A. P. Munning & Co.)

tion wheels. Such protection may save much damage to property and injury to workmen should the wheel burst while running at a high speed. Another useful device is a glass shield, Fig. 114, to protect the eyes from flying chips or dust. This shield may be easily constructed to suit any special requirements.

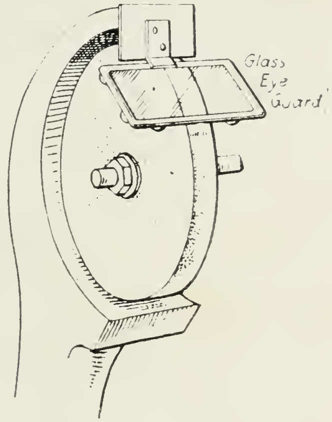


Fig. 114.—Simple Glass Shield to Protect Eyes from Emery Dust

PORTABLE GRINDERS

For heavy castings or large objects, a portable grinding apparatus is most useful. This simple device consists of a flexible shaft equipped with a pulley at one end and a spindle at the other extremity for a polishing or grinding wheel. The pulley end is anchored to the floor. A round belt, passing between a grooved line shaft pulley and the anchored pulley, drives the polishing or grinding wheel. The workman moves the wheel over the work instead of vice versa, as when using a lathe-mounted grinder.

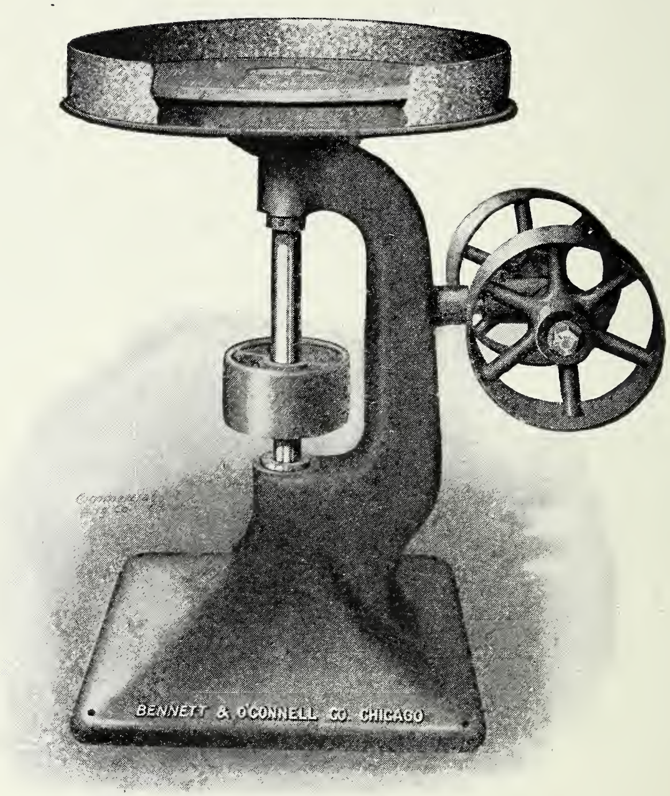


Fig. 115.—Disc Surface Grinder and Polisher

(Bennett O'Connell Co.)

SURFACE GRINDERS

A disc-surface grinder and polisher is shown in Fig. 115. As will be noted, a horizontal steel disc is secured to an upright driving shaft. A cloth circle is cemented to the disc, sized with a suitable grain of emery. The steel disc can be easily removed, reversed, or replaced by another disc. This machine is exceptionally useful for the preparation of objects presenting flat surfaces.

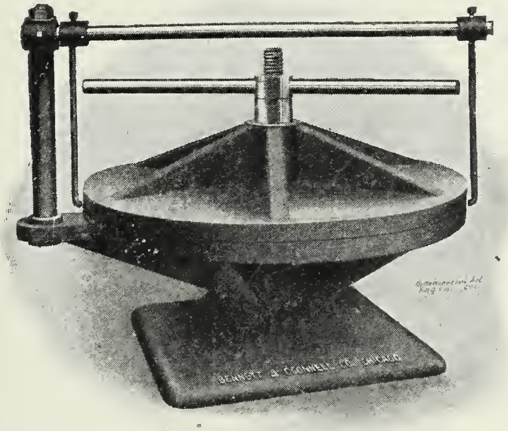


Fig. 116.—Press for Gluing Emery Cloth to Grinder Discs.

(Bennett O'Connell Co.)

A special press, Fig. 116, is required for cementing the emery cloth to the steel disc.

DUST COLLECTOR HOODS

Polishing, buffing, and grinding operations produce much metallic and abrasive dust. Such dust, if not removed as soon as formed, fills the air, settles upon finished work, and injures the health of the workmen. Even though many state laws require that suitable ventilating devices be provided in rooms devoted to work of this nature, the removal of abrasive dust should be considered also from the standpoint of efficiency. Fresh air and clean surroundings are productive of efficient work.

While open windows or roof ventilators will assist in maintaining air circulation, the only positive method is a blower system. If hoods, such as illustrated in Fig. 117, are placed around the polishing, buffing, and grinding wheels, and each hood connected through a pipe to an exhaust fan, all of the dust particles can be collected as they are thrown from the wheel. A very satisfactory motor driven fan for ventilating the plating room is shown in Fig. 118.

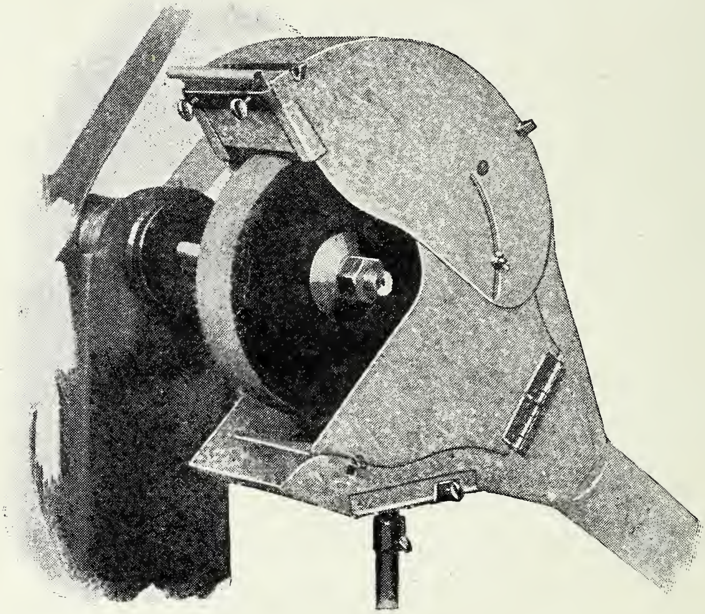


Fig. 117.—Hood with Adjustable Top

(General Platers' Supply Co.)

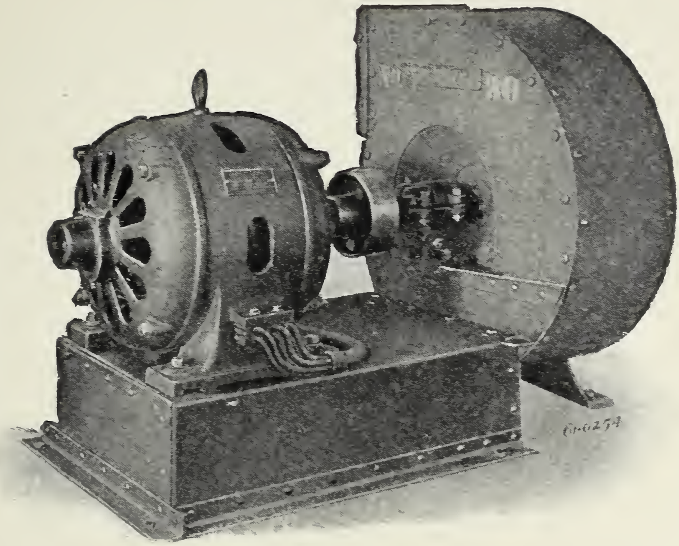


Fig. 118.—Motor Driven Ventilating Fan

(Wagner Electric Mfg. Co.)

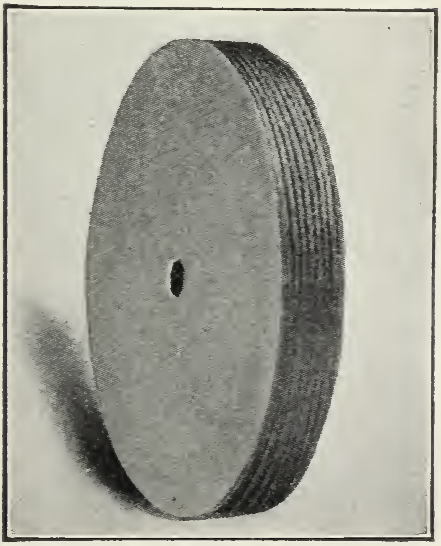


Fig. 119.—Wooden Polishing Wheel

POLISHING

The machinery required for grinding, polishing, and burring operations has been described. It is therefore necessary to consider the preparation and use of the wheels employed to obtain the various surface finishes.

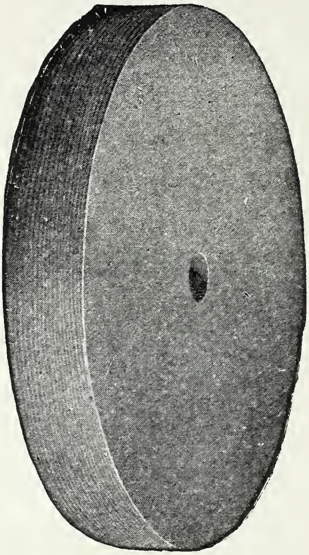


Fig. 120.—Canvas Polishing Wheel

Polishing is accomplished with disc wheels on whose perimeter emery is set in glue. Such wheels are constructed of wood covered with leather, or formed of many layers of canvas, felt, leather or similar materials.

POLISHING WHEELS

The wooden wheel is constructed, as a rule, of ½-inch discs glued together, the alternate layers with the grain crossed, and dried under pressure. A leather band is secured to the circumference, and it is upon this surface that the emery is glued. Wooden wheels are available in any diameter over 8 inches and any thickness greater than 1 inch.

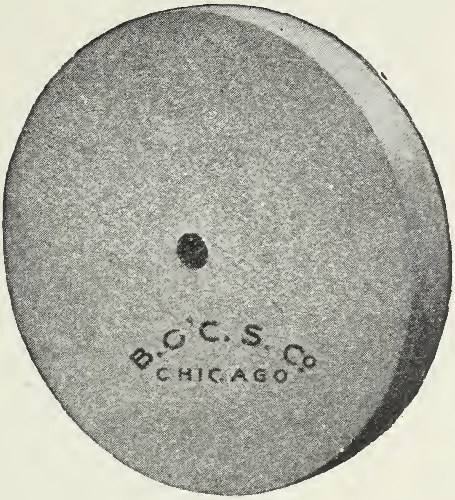


Fig. 121.—Felt Polishing Wheel

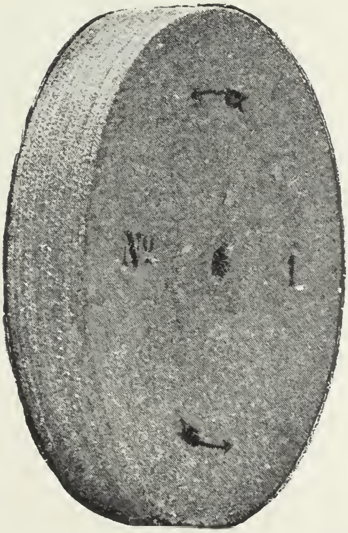


Fig. 122.—Loose Sheepskin Polishing Wheel

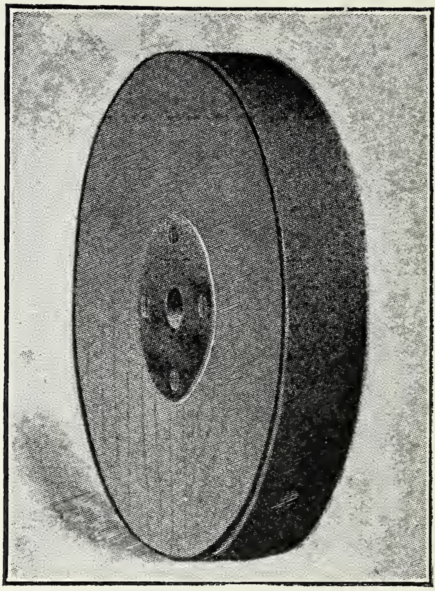


Fig. 123.—Bull Neck Polishing Wheel

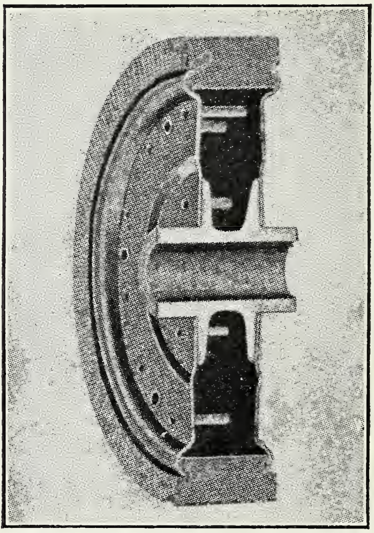


Fig. 124.—Cross Section of Compress Wheel

The canvas wheel, while often less expensive than other types, is quite serviceable. It is built up of many layers of strong, tightly-woven canvas discs cemented together. An advantage claimed for this wheel is its resilience. This assists materially in lessening fatigue of the workman.

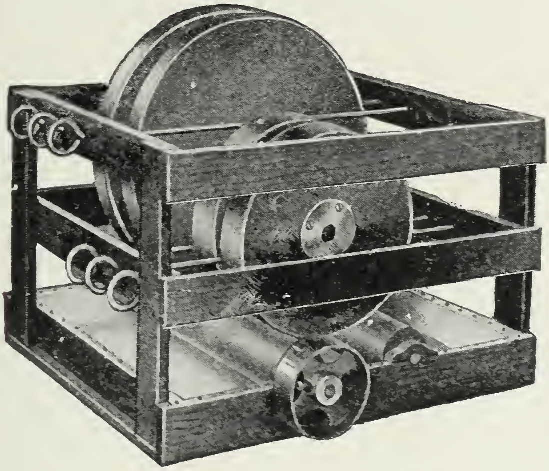


Fig. 125.—Polishing Wheel Cleaner

(Crown Rheostat & Supply Co.)

Felt, cloth, and paper wheels are sometimes used, their action being similar to the canvas.

The all-leather polishing wheel is especially adaptable to fast, hard grinding. Because of its elasticity or pliability, it quickly adjusts itself to any unevenness in the emery coating. This quality allows a longer life to the emery surface. If desired, the leather wheel may have its polishing surface so treated that it will accomplish the identical results of the emery or carborundum wheel. Again the

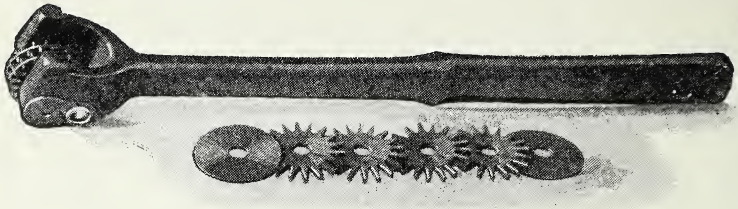


Fig. 126.—Huntington Emery Wheel Dresser for Truing Wheels While Running at Full Speed.

(Crown Rheostat & Supply Co.)

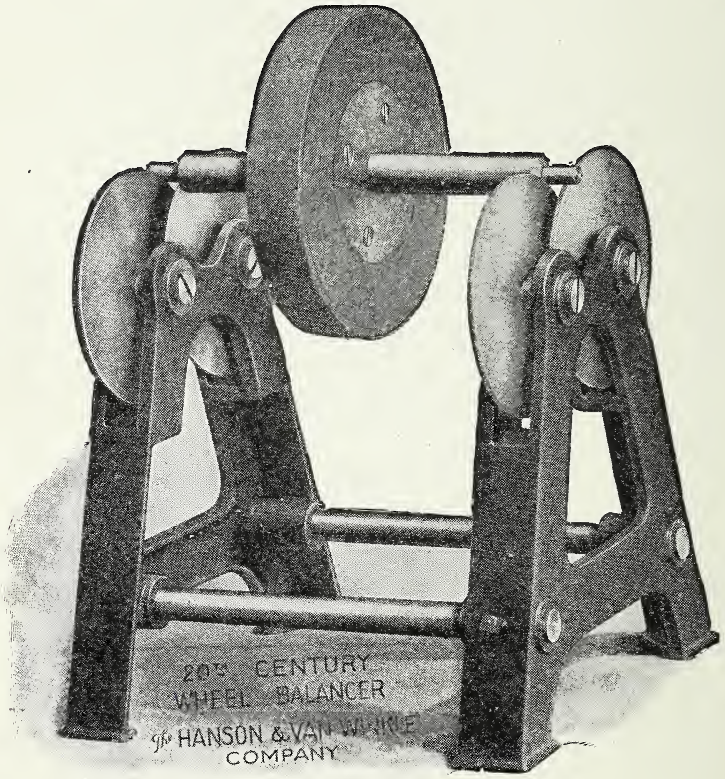


Fig. 127.—Balancing Tool for Polishing Wheels, Pulleys, Armatures, etc.

(Hanson & Van Winkle Co.)

surface may be formed to fit any particular work. For articles having irregular edges, a soft sheep-skin wheel produces the best results. Various forms of polishing wheels are shown in Figs. 119 to 124 inclusive.

CLEANING THE WHEEL

After prolonged use and many glue and emery applications, the polishing surface becomes rough and uneven. The best remedy is to remove entirely the thick coating when a new cutting surface may be applied. A polishing wheel cleaner, similar to that shown in Fig. 125, may be employed for this work. By placing the worn wheel in the machine, and allowing it to run for a few minutes with the water just touching the rollers, all of the glue and emery will be removed. Should such a device be unavailable, place the wheel on the lathe and loosen the emery particles by pressing a rough metallic edge, such as a broken casting, against the revolving wheel face. The surface may then be cut down by the aid of a wheel trimmer, an instrument which is shown in Fig. 126. It may be further smoothed by wetting the wheel with a piece of water-soaked waste or cloth held with one hand while a stone, manufactured for such purposes, is held against the surface with the other hand. As soon as the prepared surface is dry, the usual glue and emery applications may be made. A balancing stand to test the wheel for rotative balance is shown in Fig. 127.

EMERY APPLICATIONS

It may be well to add a word of caution in regard to the gluing operation. Unless some degree of care is exercised, a wheel prepared for fine work will have a polishing surface sprinkled with a few grains of coarse emery left on it by the glue brush. Perhaps the brush or glue pot, in such instances, had previously been used in preparing a coarse emery wheel. A wheel surface containing several grades of emery cannot possibly be used with any expectation of producing fine work.

It is possible to use the same polishing wheel for either roughing or fining operations. While the wheel may be run dry for iron or steel fining it is best to apply slight quantities of tallow for brass work.

Grease wheels are usually set up with a fine grade of emery. Oil may be used with success for keeping the grease wheel polishing surface lubricated, but the emery deposit will not be as well preserved as when tallow is applied. Experience has shown that a coarse-grained material, such as cast iron, will finish with best results when No. 140 emery is used. No. 160 emery is required for the fine-grained malleable iron, drawn-steel parts, drop forgings, and the like. Old emery is removed in the usual manner and new applications are made as previously directed.

In general, it is a good policy to keep several wheels prepared and held in reserve. The extra cost is negligible in comparison to the expense of holding up production at some critical time. Without fail, all wheels should be inspected each evening, and should the examination show that new deposits are required, the polishing surfaces should be applied before closing up the shop. Thus all wheels will be dry and in good condition the following morning. Canvas wheels, which become soft, may be hardened by first immersing the perimeter of the wheel in hot water to a depth of several inches. The wheel is then rolled back and forth so that the heat will penetrate every point on the circumference. After this operation, it is placed in a press or between two boards. If the latter are used, some heavy object should be piled upon the top board so that the wheel will dry under pressure.

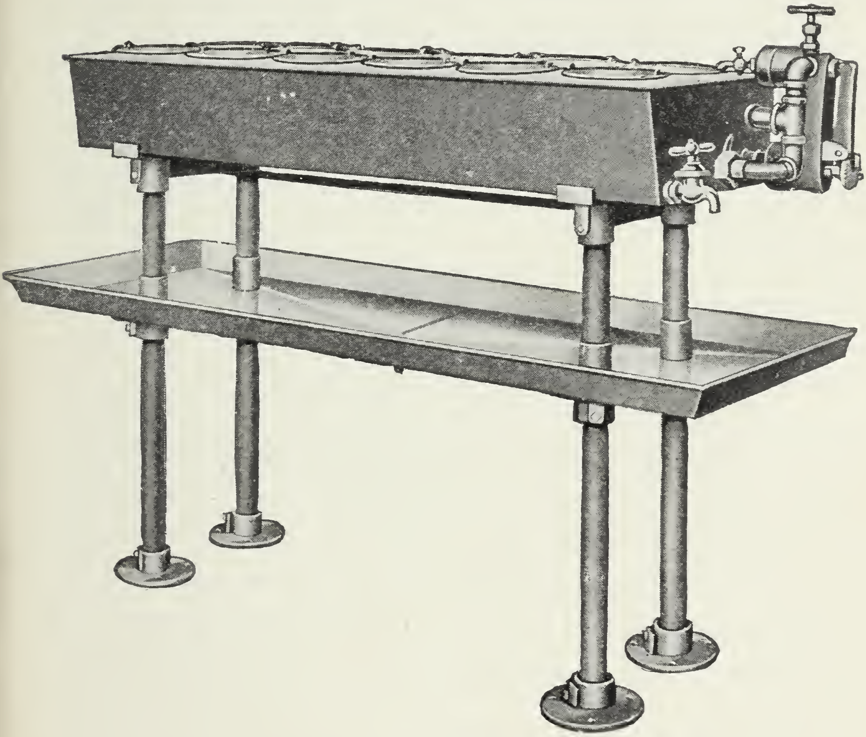


Fig. 128.—A Modern Steam Heated Glue Container

(Crown Rheostat & Supply Co.)

THE GLUE HEATER

It is not possible to heat glue in a make-shift container and expect to secure a clear, flowing liquid free from foreign matter. Under no circumstances should the glue-pot be placed directly upon the heating element unless surrounded by a water jacket. Fig. 128 illustrates an excellent type of glue heater. It will be noticed that there are several glue containers. This arrangement allows a separate pot for each of several similar grades of emery and the danger of coarse grains mixing with finer grades through the medium of one container is eliminated.

GLUING THE WHEELS

It is a simple matter to prepare a polishing wheel, but care must always be exercised to see that the job is neatly done. If the wheel is new, several coats of glue and emery are required to build up a cutting surface. Place the wheel in the lathe, and while it is turning, use sandpaper to remove any uneven points. Apply a thin coat of hot glue, free from foreign matter. The wheel may continue running for a time until the glue is nearly hard when a wet cloth should be pressed against the revolving glued surface. This procedure will produce a smooth face for the emery coating. If the polishing lathe is not required, the wheel may remain on the arbor until thoroughly dry. A new wheel, since there is no emery body to build upon, should be given two coats of glue and emery. A drying period is allowed between the coatings.

EMERY TROUGH

There is no more simple method of applying emery to the polishing wheel than through the use of an emery trough, such as is shown in Fig. 129. A glue application is made to the surface of the wheel and the latter is then rolled through the trough in which is the desired grade of emery.

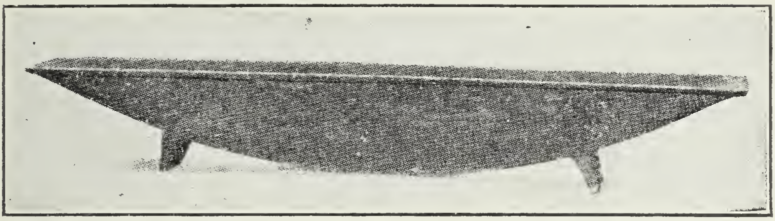


Fig. 129.—Emery Trough

(Crown Rheostat & Supply Co.)

BUFFING

Buffing is the process of finishing metal surfaces by the use of cloth wheels charged with a special composition.

BUFFING WHEELS

Buffing wheels, more intimately termed "buffs," are constructed of less rigid material than polishing wheels. For this reason there is more "give" to them, requiring less pressure to produce the desired results. Materials such as bleached and unbleached muslin, sheeting, canton flannel, denim, and light duck are used extensively. To give maximum wear, the layers or discs of cloth are arranged with the

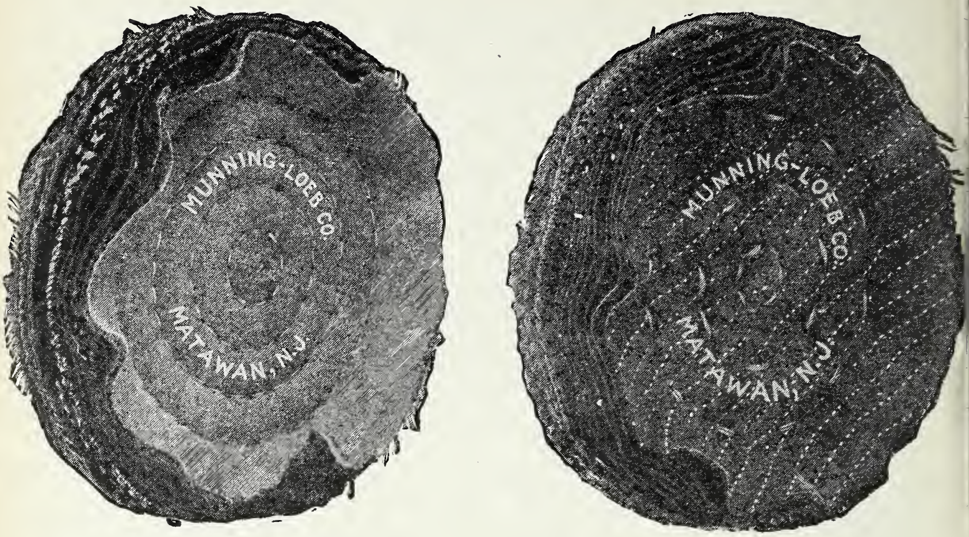


Fig. 130.—Woolen Cloth Buffs

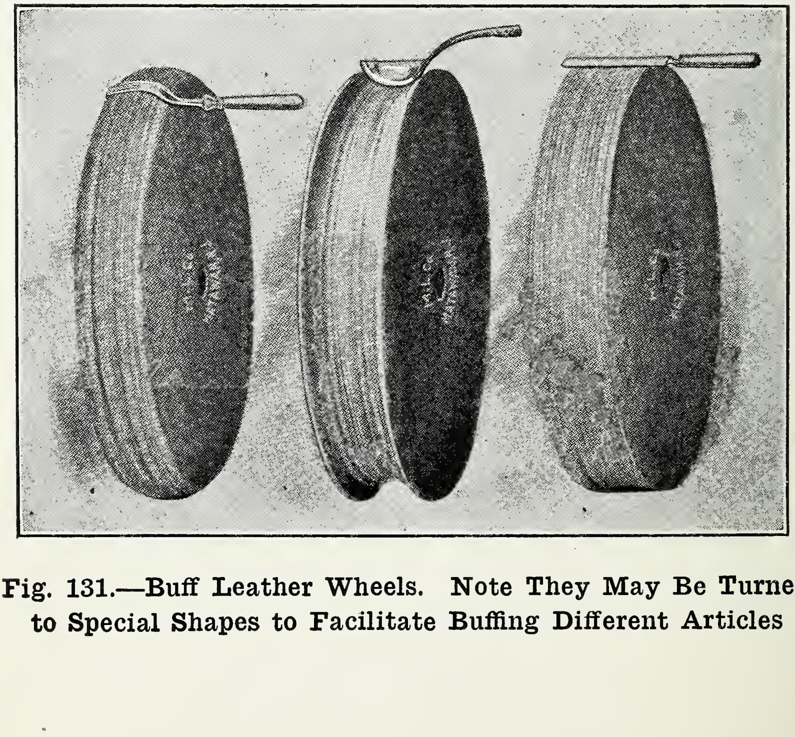


Fig. 131.—Buff Leather Wheels. Note They May Be Turned to Special Shapes to Facilitate Buffing Different Articles

threads crossing each other in different directions. A number of such discs are assembled into sections about 3/16 inch thick and stitched together, the stitching being in concentric circles 1/4 inch apart. Any number of these sections may then be cemented together under pressure to secure the desired wheel thickness. Typical woolen cloth buffs are shown in Fig. 130.

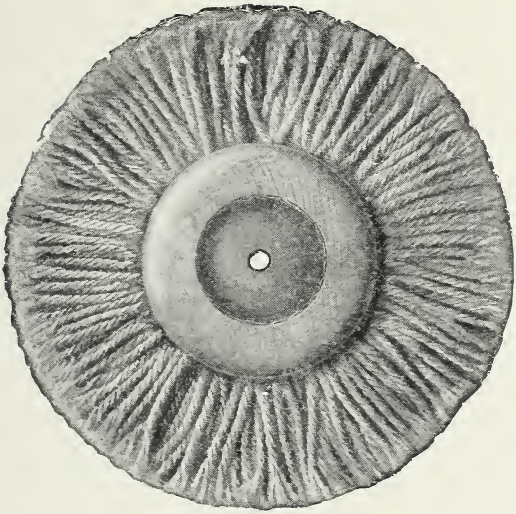


Fig. 132.—Cotton Wick Buff Wheel

It is not possible here to give the type of buffs required for the various forms of work. Each manufacturer separates his product into various grades and for each he claims special advantages. While, in general, it might be said that unbleached muslin is used to best advantage in buffing silverware and other fine work, bleached muslin for brass, copper, and heavily-nickeled parts, sheeting for gold and silver, yet experience and the manufacturer's advice will best tell the exact grade required to produce the finest results. These wheels may be formed to handle various classes of work as the buff leather wheels are in Fig. 131. A cotton-wick buff wheel is shown in Fig. 132.

BUFFING COMPOSITIONS

Various compositions may be used with buffing wheels to increase the cutting speed or assist in forming a smooth finish. Tripoli, crocus, pumice, lime, and rouge, marketed perhaps under a trade name, are all efficient. Tripoli is a silicious substance and an excellent abrasive. There is nothing in its composition to assist in holding the particles together or to make it cling to the wheel surface. Tallow or other grease is therefore mixed with the tripoli for con-

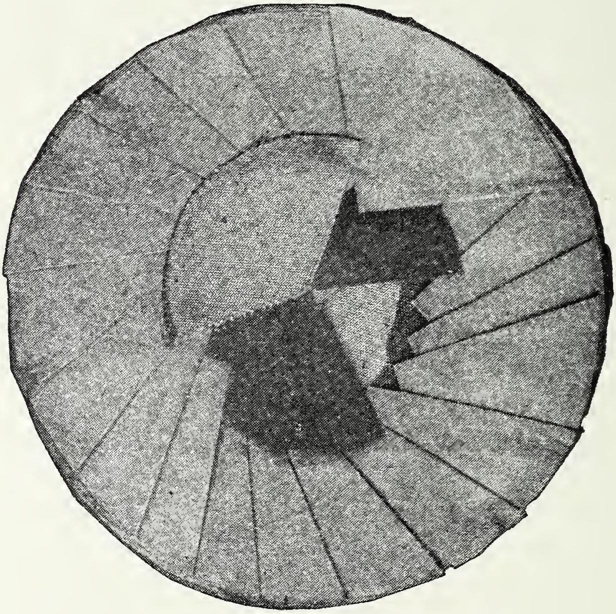


Fig. 133.—Stubless Triplex Buff

venience in applying the composition. It can be obtained in many degrees of fineness.

Crocus is a red iron oxide. It is prepared in both powder and cake form. Crocus is used on work requiring a high polish and fine finish.

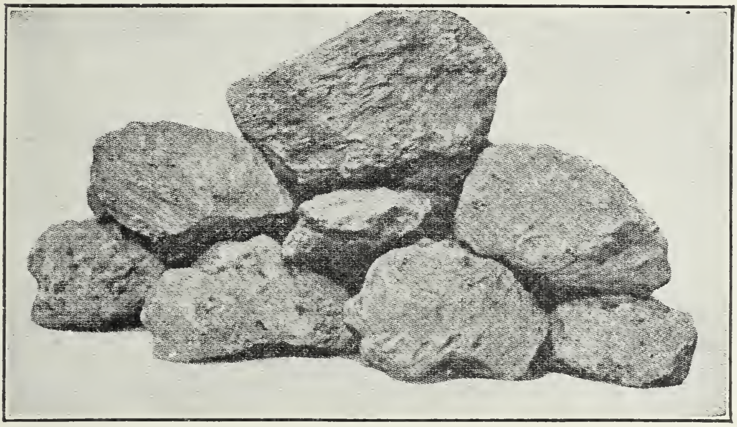


Fig. 134.—Lump Pumice

(Crown Rheostat & Supply Co.)

Pumice stone, as its name implies, is composed of pumice usually imported from Italy. Very excellent "old brass" finishes may be obtained with its use.

Lime compositions can be obtained in powder form ready to mix with grease or water. While they are especially good compounds for nickel, copper alloys can also be readily finished with them to a high luster.

Rouges, formed from oxides, are usually red or black in color. Red rouge is the most popular and is used for coloring and fine polishing. Black rouge is manufactured for buffing materials on which the red color would be objectionable.

Rotten stone may be obtained in both powdered and lump form. It has much the same characteristics as the foregoing abrasives.

Emery can be obtained in cake form, the emery being mixed with the hard grease of the cakes. It may also be secured, as is the case of the other compositions, in barrel quantities, the mixture of grease and abrasive having the same qualities as are found in the cake form.

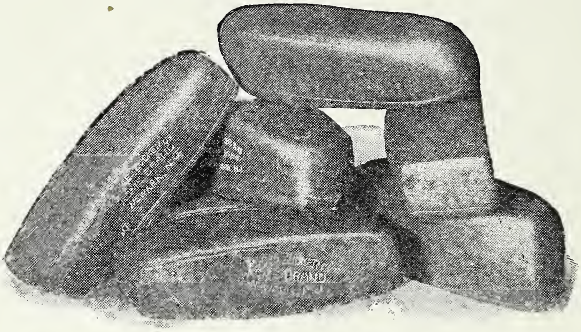


Fig. 135.—Finishing Composition in Cake Form

(A. P. Munning & Co.)

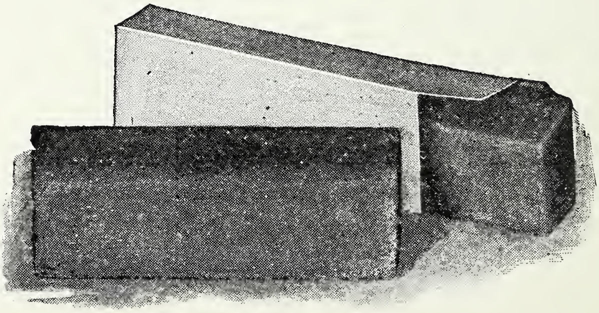


Fig. 136.—Cutting Down Composition in Cake Form

(A. P. Munning & Co.)

Lump pumice is shown at Fig. 134 and the crocus composition used for coating buffing wheels is made

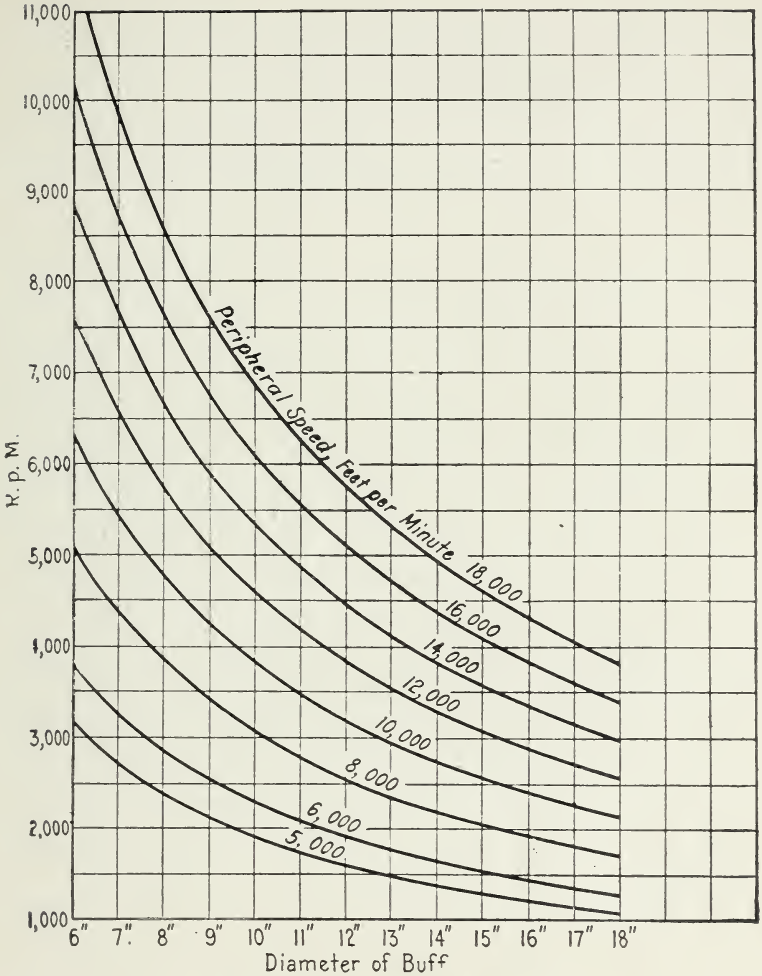


Fig. 137.—Speed of Buffs
(Courtesy of A. P. Munning & Co.)

The above chart shows at what speed any size buff must be run in order to give a predetermined peripheral or cutting speed at the face. For example, suppose we have an 18-inch buff and wish to have 14,000 feet of the edge of the buff pass the surface of the work per minute. Taking the 18-inch line on the base, and following it up to where it crosses the 14,000 curve, then following horizontally to the left, we find that the buff must have a speed of about 3,000 revolutions per minute.

up into the handy cake form shown in Fig. 135. A cutting down composition may also be procured molded into cakes, as shown in Fig. 136.

SPEED OF BUFFS

No definite advice can be given relative to the speed of polishing and buffing wheels. Only the workman, by watching carefully the work he is producing, can judge whether the speed is correct. The chart shown in Fig. 137, however, may be used as a safe guide toward the regulation of buffing speeds.

SCRATCH BRUSHES

There are many instances where treatment with a steel or brass scratch brush improves the surface of an article. Many pleasing effects may be secured on dipped or plated articles if they are lightly touched against a rotating scratch brush. As has been previously stated, the final metal deposit is much improved if the work is removed from the tank, scratch brushed to lay down the grain of the metal, and returned to the solution for the final plating operation. Surfaces thus treated are exceptionally durable. Illustration of a scratch brush is shown in Fig. 104.

BURNISHING BARREL

A power-driven ball-burnishing barrel provides a rapid and quite effective method of burnishing small articles, either before or after plating. Because small steel balls are utilized as burnishing agents, this process is similar to hand work with the exception that several thousand operations are performed at each revolution of the barrel.

A tumbling barrel cannot be converted for use in steel-ball burnishing. Since this work requires great tool pressure on the part being burnished, the barrel must be designed to concentrate the mass of pieces and balls to gain such weight as will produce the necessary pressure on the bottom layers. As a protection against excessive bruising, a lining of maple, or other hard wood, is provided.

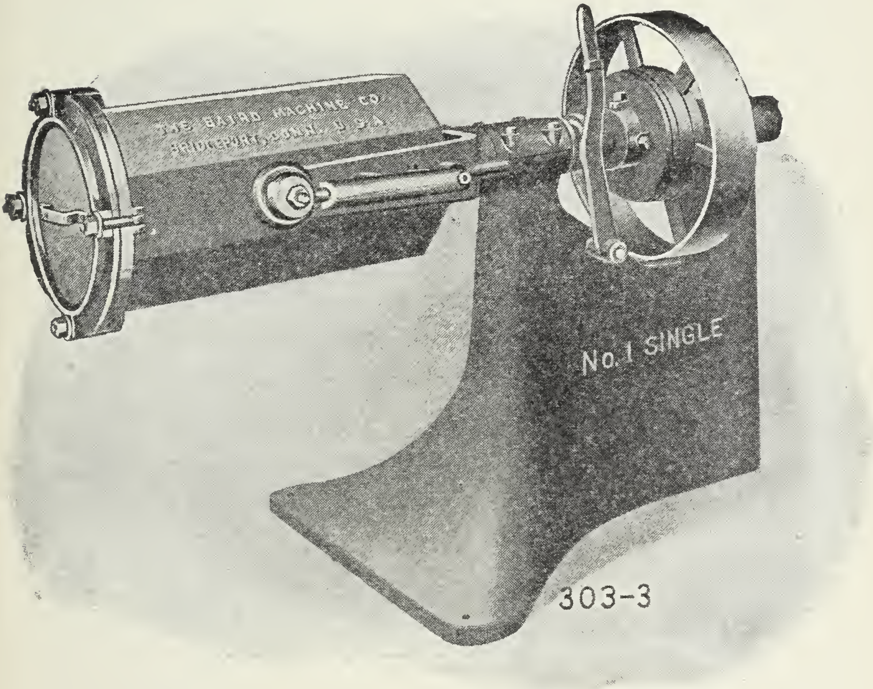


Fig. 138.—Ball Burnishing Machine

(The Baird Machine Co.)

The burnishing process is quite simple. The pieces to be burnished are placed in the barrel with several hundred pounds of small steel balls. There is little danger of using too large a quantity of steel balls; rather the risk lies in the other direction. A good plan is to allow approximately twice the quantity of balls as of work, so the articles will not strike against each other; but in all instances the barrel must be completely full. Dissolve six to ten ounces of good soap, free from alkali, in a bucket of hot water. As soon as this solution is poured into the barrel, the cover may be secured in place, and the machine set to revolving.

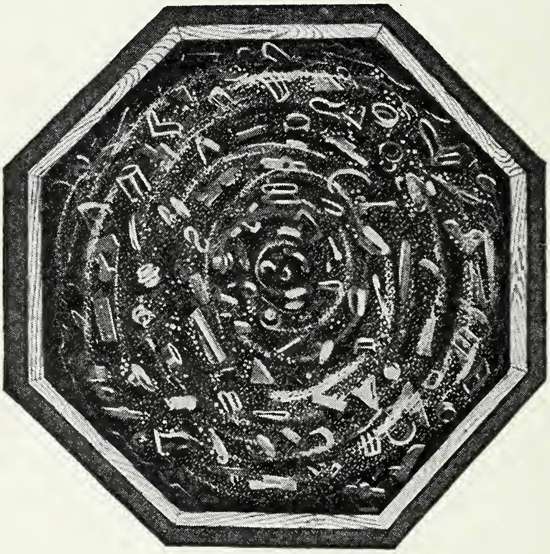


Fig. 139.—No Wave Action in a Full Barrel. The "Baird" Type of Ball Burnishing Machine

It is suggested that in selecting the size of the balls for burnishing, attention should be given to the character of surface of the articles. Steel balls may be secured in sizes from 1/8 inch to 1/2 inch in diameter. For work having crevices or depressions, the smaller size balls will obviously produce the best burnishing effect. A mixture of several sizes is permissible.

The manager of the plating room will find it to his advantage to construct the sifting device shown in Fig. 140. It will be seen that an upper frame with a screen bottom rests upon a water-tight box. The latter has the same width as the upper frame but is 24 inches longer. Cleats secured to the upper edges of the box serve to prevent a side movement of the frame, yet allow lengthwise motion. The wire mesh of the frame should be of such coarseness that, when the contents of the barrel are poured into the separating device, the balls will fall through into the box beneath, leaving only the burnished articles on the screen. The upper frame, after the removal of the pieces, may be pushed aside and the steel balls returned to the barrel.

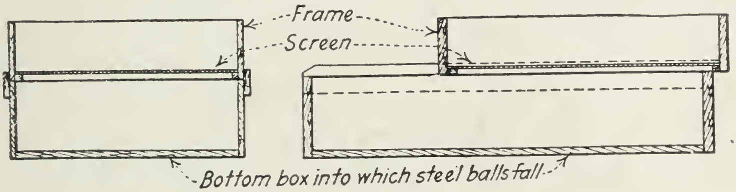


Fig. 140.—Separating Device for Use with Steel Ball Burnishing Barrel

LACQUERING

Tarnish will soon appear on newly-plated work, or articles of brass and copper cleaned by bright dipping. If, however, such new surfaces are protected from moisture and chemicals by a lacquer coating, the original luster is preserved. Moreover, the article may then be cleaned with a damp cloth without endangering the finish. Most of the brass and nickel-plated hardware, automobile accessories, electrical fixtures, and scientific instruments manufactured at the present time, are treated with either transparent or colored lacquer.

The application of lacquer calls for skill, clean materials and patience. The consistency of the fluid must also always be given careful consideration. If the body is too heavy, a thinner one of the same grade as the lacquer must be added to prevent the formation of ridges or ripples. On the other hand, a lacquer that is too thin will not wear well and may show iridescent colors. The same precautions must be exercised in preparing the work for lacquering as for plating. Grease or moisture is often the cause of a cloudy or spotted finish. Care must therefore be taken to see that steam from the plating and dipping baths does not condense on the articles being prepared for the lacquer application. It is not advisable, however, to hold the work in a drying oven until ready for lacquering, since the best results are obtained when the temperature of the articles, surrounding atmosphere and lacquer are as closely identical as possible.

THE LACQUER ROOM

Ideal conditions for lacquering can only be realized when a separate room is equipped for the work. Such a room should be laid out with as much care and forethought as possible. Ventilators should be so designed that there will be a constant supply of fresh air and a corresponding removal of all fumes. Dust and moisture, the presence of which will result in inferior work, must positively be eliminated. Efficient lacquering can be accomplished only when the light is sufficiently strong to enable the operator to easily see the results obtained. Since the materials used in compounding lacquer are quite inflammable, the incandescent lamp is the only artificial light that may safely be employed. Stoves should not be used in the lacquer room and heat must, therefore, be obtained from steam or hot water radiators.

A large part of the unpleasant fumes can be eliminated from the work room if the lacquered articles are placed in a ventilated drying oven until the coating has hardened. An oven for this purpose may be constructed in one corner of the room, and should be of sufficient capacity to hold the maximum estimated production. Suitable racks should be placed about the walls for the small articles, while provision should be made for hanging larger work from ceiling hooks. The oven temperature should approximate 100° F. This may be maintained by steam coils, the regulating valves being placed outside the oven to prevent steam from escaping inside.

LACQUER APPLICATION

Lacquer can be applied either by spraying, brushing, or dipping. Spraying is now considered the cheapest and quickest method of lacquering. Shops, therefore, which can obtain a compressed-air supply will find it most advantageous to install the spray system. Under an air pressure of fifty or sixty pounds per square inch, a spray "pistol", in the hands of a skilled workman, will quickly distribute a thin coating over the most difficult surface. Even should the compressed air supply be unavailable, a small hand sprayer will give satisfactory results.

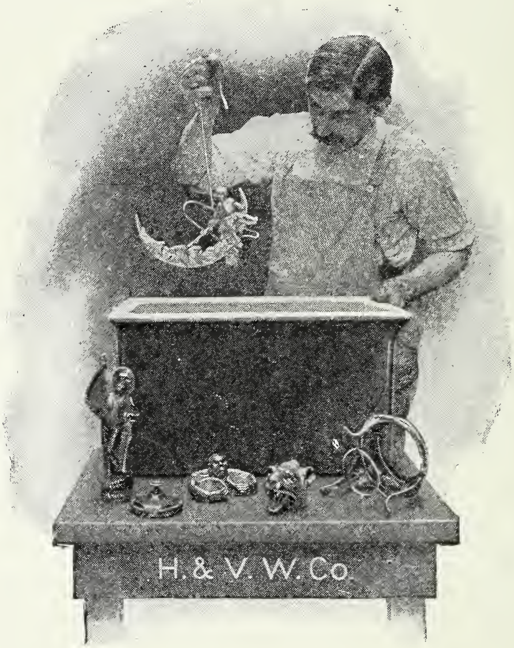


Fig. 141.—Method of Lacquering by Dipping

(Hanson & Van Winkle Co.)

For brush applications the lacquer should be thinned down to the minimum point consistent with good work. A soft bristle, badger hair brush should be used, flowing the lacquer over the surface in long, even strokes. A perfect finish cannot be obtained with a stiff, inferior brush. The method of lacquering by dipping, shown in Fig. 141, is used for quick results.

Where it is necessary to lacquer large amounts of articles in a minimum time, and where quantity production is desired rather than quality of finish, the dipping process will prove superior to other methods. The dip tank should be as small as possible, yet of sufficient size to handle the articles to be coated. The tank itself should be either enameled iron, glass, or earthenware. Avoid the use of tanks of metal, such as copper, brass, zinc, or galvanized iron; these will soon destroy the original color of the lacquer. Drain trays, arranged as shown in Fig. 142, will permit the surplus lacquer to flow back to the tank as it drips from the dipped work. If a ventilating hood is placed directly over the dip tank and drain trays, the workman will not suffer any inconvenience from the fumes. A cover for the tank should be provided to prevent

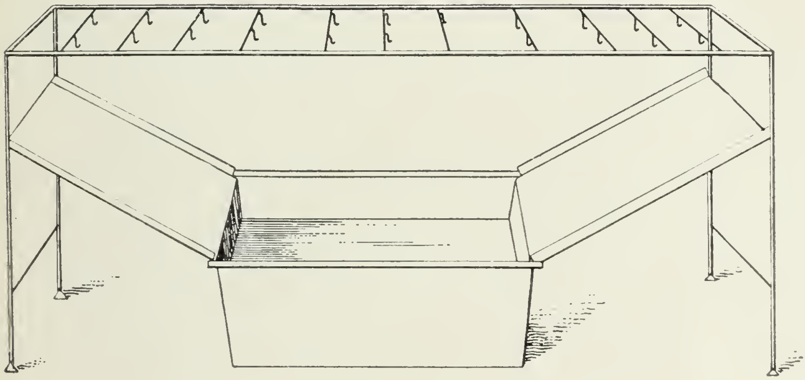


Fig. 142.—Simple Arrangement of Lacquer Dip, Drain Boards, and Drying Rack

evaporation and to keep out dust, grease, and moisture.

Iridescent coloring caused by too thin lacquer, or white, cloudy spots resulting from grease, may often be removed by the application of a second coat of lacquer. If this fails to repair the faulty work, the lacquer may be entirely removed by dipping in hot potash or lye solution.

After cleaning in fresh water and thoroughly drying, the fresh application of lacquer can be made.

COLORED LACQUER

While transparent lacquers are used to a great extent, color finishes can be employed with excellent results. Prepared dyes can be obtained and added to transparent lacquer to produce the desired shade. It is a good plan to mix the colored preparation the day before it is required, since standing improves the solution. Manufacturers, as a rule, produce dyes for special lacquer work and the operator will do well to consult the producer, or a catalogue, to ascertain the grade required for his particular needs.

CHAPTER X

USEFUL REFERENCE DATA

(A) The Maintenance and Repair of a Plating Generator—Building Up—Low Voltage—Reversal of Current Direction—Commutator Sparking—Armature Troubles—Testing for Open Circuit—Testing for Short Circuit—Testing for Grounds—Field Troubles—Bearing Troubles—Unusual Noises—(B) The Transmission of Power—Shaft Drive—Pulleys—Belts—Rules for Speed—(C) Resuscitation from Electric Shock or Asphyxiation—Quick Action—Preliminary Treatment—Loosen Clothing—Resuscitation—Warmth—Patience—(D) Antidote for Poisons—(E) Conductivity of Common Metals—(F) Comparison of Thermometers—(G) Fluxes for Soldering or Welding—(H) Miscellaneous Data—Amperes Required to Plate One Square Foot of Surface—Weight of Metal Deposited per Amperehour—Round Copper Conductors for Plating Currents—Decimal Equivalents.

(A) THE MAINTENANCE AND REPAIR OF A PLATING GENERATOR

Nothing can so retard plating room production as the irregular operation of the generator. An unreliable source of current supply will contribute more than any one thing to poor quality of work and the general inefficiency of the plant. The plating generator is not a machine of mystery. A little care exercised in its management will reward the operator with constant and unfailing service. At times, however, troubles may arise, and the following suggestions are made with the purpose of assisting the plater to locate and repair them.

BUILDING UP

A self-excited generator may not, upon starting, produce an e.m.f. This may indicate that the residual magnetism in the field poles is insufficient in strength to induce an e.m.f. in the armature windings. The armature e.m.f. serves to increase the field excitation, ''building up'' the generator as the latter increase continues to induce a larger e.m.f. in the armature.

Should the generator fail to build up, the natural inclination would be to search for a break in the field circuit. Excessive resistance, caused by poor terminal connections, or even light brush contact, might also act to prevent building up. Again, a short circuit in either the field, armature, or outside connections should be looked for. Should investigation fail to disclose any mechanical defects, it will be necessary to disconnect the field from the armature and excite the former for a few moments from some outside source. This operation will strengthen the residual magnetism.

LOW VOLTAGE

Should difficulty be experienced in obtaining the rated voltage, some note should be taken of the shunt field rheostat to determine whether the resistance is excessive. Low voltage is also the result of driving the generator at a speed less than that indicated on the name plate. This may be checked with a speed indicator.

REVERSAL OF CURRENT DIRECTION

The electroplater will quickly recognize a reversal of the current direction. This is caused by a change in the residual magnetism when the machine is idle. Lightning, an outside current, or magnetic influence from a nearby dynamo may effect this reversal in polarity. The remedy is to excite the generator field for a moment in the correct direction from some outside current supply.

COMMUTATOR SPARKING

Undoubtedly the most apparent form of generator trouble is a sparking commutator. There are several causes of poor commutation, the chief of which is an overloaded generator. A simple short circuit, caused by a bar falling across the supply mains, or work touching the anodes in the tanks must be guarded against. Perhaps, also, the generator capacity may be insufficient for the plating requirements.

A rough commutator will always cause sparking. A dark glazed surface is a condition to be strived for. Excessive sparking will quickly groove and pit the commutator and unless some remedy is applied, will injure it beyond repair. A slightly rough surface can be quickly smoothed with fine sand paper. Under no circumstances should emery cloth be used, since the emery dust, which is a conductor of electricity, may lodge between the commutator bars, causing short circuits. If the commutator is very rough, the armature must be removed from the machine, centered in a lathe, and a light cut taken from the pitted copper surface. Often, when the brushes vibrate, the cause is discovered to be a high or low commutator bar. These bars are often held in place through the aid of a threaded ring on the outside of the commutator. If possible, the bar should be driven back in place and the ring screwed up tight. In this case, it is absolutely necessary that the commutator be trued up in a lathe. To keep the commutator surface clean, it should be treated once a week with vaseline applied with a cloth free from lint. Too much lubrication is, of course, detrimental, since it gums on the brushes and retains dust and grit.

Poor brush contact is another cause of faulty commutation. Graphite-treated woven wire or special brushes for plating generators should always be used. The brush should never fit so tightly in the holder but that the spring can press it snugly against the commutator. The brush pressure may be deemed correct when its bearing against the commutator is about 2 pounds per square inch of contact surface. A small spring scale may be used to determine this pressure. It must be remembered that if the brushes bear too hard they will grind and the copper dust thus formed will lodge between the segments, causing short circuits and sparking.

Weak field excitation may be the cause of sparking brushes. Usually this condition may be determined by noting the voltage across the terminals; a low voltage indicating insufficient field excitation. The remedies for this trouble have already been discussed.

Short circuits and grounds in the armature will produce sparking at the commutator. Tests and remedies for this condition will be described later.

ARMATURE TROUBLES

Should armature trouble appear, it may be due to an open circuit, a short circuit, or a ground in the winding. Excessive heating may also be caused by overloading the generator or by conduction from a defective, hot bearing.

TESTING FOR OPEN CIRCUIT

The usual methods employed in testing for broken armature leads and open circuits are as follows: A strip of brass is substituted for one of the brushes, so that but one commutator segment is touched by it at a time. A low reading ammeter is then connected through a low voltage battery to the brass strip and the other regular brush. The armature is rotated by hand very slowly and the ammeter readings noted. Most plating generators have two leads soldered to each commutator bar; a break in one of these leads causes a reduced ammeter deflection; a break in both causes a complete open circuit and there is no deflection indicated. The broken lead may be traced from the bar upon which the brass strip rests at the moment of reduced ammeter deflection.

Open circuits are found by testing in a manner similar to that just described. Instead, however, of connecting one meter lead to the regular brush, contact is made with the commutator by a second brass strip. This latter strip is so held that it at all times touches a bar adjacent to one upon which the first brass strip rests. As in the first test, an open circuit is indicated by no deflection of the ammeter. It is, of course, understood that there will be no deflection of the pointer as the strips pass over the insulating mica when the armature is rotated. There should be no confusion of this with the action of the meter when an actual broken circuit is found.

TESTING FOR SHORT CIRCUITS

A short circuit in an armature is found with the same equipment as required for the open circuit test. As the two brass strips are touched against adjacent commutator bars and the armature slowly rotated, an ammeter reading above normal indicates a short circuit in the coil section connected to one of the bars.

TESTING FOR GROUNDS

A ground is any connection between a winding and the core or frame. Grounds in an armature are usually found by connecting a battery to the brushes of the generator. A low-reading voltmeter is then observed while one of its leads is touched against each commutator bar, the other lead being in contact with the shaft or core iron. A voltmeter deflection indicates, of course, that there is a ground or connection between the core and the winding. The ground may be localized by noting the bar where the voltmeter shows the least deflection.

FIELD TROUBLES

As a rule, the field gives very little trouble. Excessive heating may be traced to a short circuit, to high terminal voltage, or to the conduction of heat from the armature. A short circuit may be easily located by noting, with a voltmeter, the difference of potential cross each field winding. An open circuit or an exceptionally high resistance can be noted by connecting a battery and ammeter in series with each of the coils in turn. If there is no deflection of the pointer it will naturally indicate an open circuit.

BEARING TROUBLE

Bearing friction absorbs power, causes wear, and, if the friction is excessive, produces great heat. Clean, smooth bearing surfaces, between which is a thin film of good lubricant, should show but a slight rise in temperature. A good grade of mineral oil should be freely used; if possible, the oil wells should be filled each day. Abrasive dust from the polishing room may work into the bearings, causing a scored and roughened shaft. Bearing alignment is quite important, as is also the shaft and bearing fit. Precautions should be taken to guard against bending the shaft, since excessive vibration will then result.

UNUSUAL NOISES

Any large generator produces certain characteristic noises while operating. It is the unusual noise that should be at once noted by the plater and an investigation made as to its cause. A slipping belt gives a screeching sound. This may be due to insufficient belt tension, but usually it is caused by an overload thrown on the generator. Adjustments should be so made that there will be little pounding of the belt. If a scraping noise is heard, the generator should be immediately stopped. It may be found that a pole shoe is loose, that the bearings have worn to such an extent that the armature is rubbing against the field poles, or that the armature is unbalanced. Commutator noises may be due to roughness, chattering of brushes, or the need of a lubricant. Remedies for these troubles have already been suggested.

(B) THE TRANSMISSION OF POWER

While the subject of mechanical power transmission does not concern the electroplater to so great a degree as it does a machine shop superintendent, yet a few simple precautions taken at first will prevent interrupted service at a later time.

SHAFT DRIVE

If it is necessary to use overhead shaft drive for the various machines, care should be exercised to place the hangers in alignment. Should the distance between the hangers be so great as to allow the shaft to bend, even slightly, the wear on the bearings will be excessive. Compute carefully the size of shaft required to transmit the required power; then allow a good factor of safety. It will be remembered that the slower the shaft speed, the less power it will safely transmit. Countershafts, which are run at a slow speed should, therefore, have a larger diameter than the drive shafts.

PULLEYS

Ordinarily, paper or wooden pulleys will give better satisfaction than iron ones; the friction is greater and they are much lighter. When pulleys are to be added to a shaft, split iron or pressed steel pulleys may be used to advantage, since they may be installed without disturbing the shaft.

BELTS

Although in many instances it is necessary, on account of lack of space, to mount the motor on the ceiling, such mounting demands a vertical belt drive; an inclined belt will give better results, and one that is horizontal is best of all. Long belts need not be drawn as tightly as short ones to produce the same friction; yet there is a limit even to the length. Harmful bearing friction and an injurious side to side motion of the belt are direct results of long distance between pulley centers.

RULES FOR SPEED

The electroplater is often confronted with the problem of determining the speed of shafts, countershafts, and machines, as well as the size of the required pulleys and belts. Such information may be obtained from the manufacturers of the apparatus in question, but for the convenience of the plater, the following rules are quoted, through the courtesy of the Crown Rheostat and Supply Co.:

"To find speed of countershaft in accordance with main shaft and machine. Subtract the number of revolutions of the main shaft from the number of revolutions the machine should make; divide the remainder by two. The quotient will show the number of revolutions of the countershaft.

"Example: The main shaft runs 200 revolutions per minute, while the machine should run 1,000 revolutions per minute. Deduct 200 from 1,000, leaving 800, which divide by 2; the quotient will then be 400, which is the number of revolutions the countershaft should make.

"To find diameter of pulleys on the main shaft. Multiply the diameter in inches of the receiving pulley of the countershaft by the number of revolutions the countershaft should make, and divide the product by the number of revolutions the main shaft makes.

"Example: The countershaft runs 400, the receiving pulley is 7½ inches in diameter, and the mainshaft runs 200; 400 times 7½ equals 3,000, which divided by 200 equals 15; this is the diameter of pulley on main shaft in inches.

"To find diameter of pulley on countershaft carrying belt to machine. Multiply the number of revolutions the machine should make by the diameter of pulley of machine and divide by the number of revolutions the countershaft makes.

"Example: Say machine should make 1,000 revolutions, the diameter of pulley on machine being 6 inches, and the countershaft making 400 revolutions, then multiplying 1,000 by 6 equals 6,000; dividing this by 400 gives 15, which should be the diameter of pulley carrying belt from countershaft to machine.

"To find speed of a machine. Multiply the number of revolutions of the main shaft by the diameter of pulley in inches, and divide by the diameter of receiving pulley of the countershaft. The result is speed of countershaft. Then multiply the number of revolutions of countershaft by diameter of transmitting pulley, and divide by diameter of pulley on machine. The result will be speed of machine. It should be well understood that no other pulleys but those in contact with one belt should be considered. To find the horse-power a belt will safely transmit.

Multiply diameter of pulley in inches by its revolutions per minute and the product by width of belt in inches. Divide this product by 3,000 for single belting or 2,100 for double belting, and the quotient will be the horse-power that can be safely transmitted. To find the length of the belt. Add the diameters of the two pulleys, divide by 2 and multiply by 3.1416. To this add twice the distance between centers of pulleys. This is practically correct where pulleys are not very different in size, and are to run with short belt.

"A belt velocity of 2,600 feet per minute is said to give the best results."

(C) RESUSCITATION FROM ELECTRIC SHOCK OR ASPHYXIATION

It is, of course, understood that the low voltages required for electroplating are by no means dangerous to human life. If, however, the plating generator is driven by an electric motor, a time may come when an inspection or a repair job will expose the workman to an outside power circuit of 220 to 440 volts. While a normal, healthy person will usually rally promptly from a slight shock at these voltages, instances are on record of mortalities caused by shock from currents of even lower pressure. Since the method of resuscitation from electric shock is quite similar to that from asphyxiation by poisonous vapors, a brief discussion of the subject will benefit the electroplater who is often exposed to both dangers.

QUICK ACTION

Good judgment will prompt, in the case of any accident, the placing of an immediate call for the nearest doctor. Realizing that the spark of life is hanging by the merest thread, those attending the patient will act quickly and continue their efforts with patience. In the case of gas or poisonous vapor asphyxiation, the patient should be removed at once to fresh air before the acts of resuscitation are begun. Not so with a case of electric shock. The loss of a few seconds may cause death; the work of resuscitation should be started at the earliest possible moment regardless of the position of the unconscious man.

PRELIMINARY TREATMENT

If the accident is caused by electric shock, search for and remove the wires or other conductors from contact with the injured man's body, using a board or other non-metallic agent. If the tongue appears to be swallowed, pry open the mouth with a stick of wood and pull the tongue out using a cloth or handkerchief to obtain a better grip. The tongue must then be held out to prevent it again plugging up the throat.

LOOSEN CLOTHING

For either shock or asphyxiation, loosen at once all clothing. But since the body heat must be retained to as great extent as possible, do not remove any but the tight throat apparel, such as collar or scarf.

RESUSCITATION

Lay the patient on his back, and, if convenient, arrange the head lower than the feet. Assume a kneeling position at the head of the patient. Grasping his arms at the wrists, place them over the lower ribs and press, immediately afterward swinging the arms directly up and backward, then downward again to repeat the pressing operation. Expel and fill the man's lungs in this manner sixteen times a minute in imitation of the normal breathing action. A hissing of the expelled air will indicate the work of resuscitation is being carried out correctly.

If a helper is available, the work may be accomplished more quickly and with promise of greater success by having him move the patient's legs, bending them at the knees so that the latter move upward and toward the breast at the time that the arms are extended backward. As the air is expelled from the lungs, the legs should be pulled out straight.

WARMTH

At all times the patient should be kept as warm as it is possible to make him. Wrap the exposed parts in blankets without, of course, interfering with the work of resuscitation. Do not administer hot or cold drinks until the patient is sitting up, as the possibility of choking must be avoided.

PATIENCE

It may be well to add that consciousness is not always restored in a few minutes. Results may not be seen for one, two, or even four hours in severe cases. But while there is the faintest spark of life there is something well worth working for, and no amount of fatigue should cause one to give up. Not until death has actually occurred, as may be known by the softening of the patients eyeballs, is there no hope for success.

(D) ANTIDOTES FOR POISONS

The majority of the chemicals used in electroplating are poisonous, and workmen should exercise the greatest precautions to safeguard their health. Plating room utensils should under no circumstances be used for drinking cups. It is dangerous practice to eat lunches where the chemicals are stored. Work that has dropped off the wires into the electrolyte should be recovered with some mechanical device; to dip the arms into the solution may result in skin sores, especially if it is a cyanide solution. In case of accident the following remedies will give relief until the doctor arrives:

HYDROCHLORIC ACID

If the acid solution has been swallowed, require the patient to drink tepid water to act as an emetic or an alkali solution, such as magnesia, lime, or chalk and water, to counteract the effect of the acid. Milk or the white of eggs may be used if available.

SULPHURIC ACID

Treatment same as for hydrochloric acid poisoning.

NITRIC ACID

Treatment same as for hydrochloric acid poisoning.

HYDROCYANIC ACID

Take hydrogen peroxide internally. If this antidote is not available, administer a weak solution of iron acetate. Employ artificial respiration if necessary. Keep the patient warm.

POTASSIUM CYANIDE

Treatment same as for hydrocyanic acid poisoning.

LEAD ACETATE

Administer an emetic; give milk, white of eggs.

SILVER NITRATE

Require the patient to drink salt and water solution.

SODIUM HYDROXIDE

Give vinegar, lemon juice, oil, or milk.

POTASSIUM HYDROXIDE

Treatment same as for sodium hydroxide poisoning.

COPPER SALTS

Administer an emetic, then milk or white of egg.

MERCURY SALTS

Require the patient to swallow the white of an egg.

ALKALINES

Since alkalines are the opposite to acids in chemical action, weak acid solutions may be employed as antidotes. Vinegar or lemonade is the best, but if neither is available, a *very* weak solution of nitric or sulphuric acid may be used. It is advisable to give the patient a tablespoonful of olive oil a few minutes after the acid treatment.

ACID VAPORS

Remove the patient at once to a location where there is plenty of fresh air. Cause him to inhale ammonia vapor. Keep him warm with hot blankets. Give hot foot baths. Require him to drink hot coffee, tea, or other hot beverage. Note section C.

BURNS AND SCALDS

Apply at once a light paste of baking soda or, if this is not available, starch or flour. Vaseline, vegetable oils, and cream are also soothing. Linseed oil mixed with an equal part of lime water makes a good dressing. After treating, cover the affected part with a light bandage to prevent foreign matter touching the wound.

In the case of acid or alkali burns, wash with running water. Acid burns should then be treated with lime water and linseed oil, or baking soda and soap suds. Eye burns should be bathed with lime water.

Alkali burns may best be treated by neutralizing the alkali with a weak acid, such as lemon juice, cider, or vinegar. Eye burns should be treated at once with olive oil or a solution of boric acid.

(E) CONDUCTIVITY OF COMMON METALS

Copper, because it offers the least resistance to the passage of an electric current of any metal except silver, is the metal used for most conductors. The following table, using silver as a standard, gives the relative conductivity of the common metals. When it is noted that brass has approximately 4½ times the resistance of copper, it will be seen why the latter metal is preferred for bus bars and other plating room electrical conductors.

Silver	100.00
Copper	99.9
Gold	80.00
Aluminum	34.00
Zinc	29.00
Brass	22.00
Platinum	18.00
Iron	16.8
Tin	13.1
Nickel	12.08
Lead	8.3
German Silver	7.7
Mercury	1.7

(F) COMPARISON OF THERMOMETERS

Freezing point	32° Fahrenheit
Do.	0° Centigrade
Boiling point	212° Fahrenheit
Do.	100° Centigrade

To find Fahrenheit reading, Centigrade being known:

$$F = C \times 9/5 + 32°$$

To find Centigrade reading, Fahrenheit being known:

$$C = (F - 32) \times 5/9$$

(G) MISCELLANEOUS DATA

SIZES OF MAIN CONDUCTORS

to carry a given number of amperes various distances from dynamo to tanks

(Courtesy Crown Rheostat & Supply Co.)

	DISTANCE IN FEET FROM DYNAMO TO TANKS											
Amp.	15	20	25	30	35	40	45	50	55	60	65	70
50	1/8	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	3/8
75	1/4	3/16	1/4	5/16	5/16	3/8	3/8	3/8	7/16	7/16	7/16	7/16
100	1/4	5/16	5/16	3/8	3/8	3/8	7/16	7/16	1/2	1/2	1/2	9/16
125	1/4	5/16	3/8	3/8	7/16	7/16	1/2	1/2	9/16	9/16	9/16	5/8
150	5/16	3/8	3/8	7/16	7/16	1/2	1/2	9/16	9/16	5/8	5/8	11/16
175	5/16	3/8	7/16	1/2	1/2	9/16	9/16	5/8	5/8	11/16	11/16	11/16
200	3/8	3/8	7/16	1/2	9/16	9/16	5/8	5/8	11/16	11/16	3/4	3/4
250	3/8	7/16	1/2	9/16	5/8	5/8	11/16	3/4	3/4	13/16	13/16	7/8
300	7/16	1/2	9/16	5/8	11/16	11/16	3/4	13/16	13/16	7/8	7/8	15/16
350	1/2	9/16	5/8	11/16	3/4	3/4	13/16	7/8	7/8	15/16	1	1

400	½	9/16	⅝	11/16	¾	13/16	⅞	15/16	15/16	1	2x½	2x½
450	9/16	⅝	11/16	¾	13/16	⅞	15/16	1	1	2x½	2x½	2x½
500	9/16	⅝	¾	13/16	⅞	15/16	1	2x½	2x½	2x½	4x⅜	4x⅜
600	2x¼	2x¼	2x¼	2x½	2x½	2x½	2x½	2x½	4x⅜	4x⅜	4x⅜	4x⅜
700	2x¼	2x¼	2x½	2x½	2x½	2x½	2x½	4x⅜	4x⅜	4x⅜	4x⅜	4x½
800	2x¼	2x¼	2x½	2x½	2x½	2x½	4x⅜	4x⅜	4x⅜	4x⅜	4x½	4x½
900	2x¼	2x½	2x½	2x½	2x½	4x⅜	4x⅜	4x⅜	4x½	4x½	4x½	4x½
1000	2x¼	2x½	2x½	2x½	4x⅜	4x⅜	4x⅜	4x½	4x½	4x½	4x⅝	4x⅝
1100	2x¼	2x½	2x½	4x⅜	4x⅜	4x⅜	4x½	4x½	4x½	4x⅝	4x⅝	4x⅝
1200	2x½	2x½	2x½	4x⅜	4x⅜	4x⅜	4x½	4x½	4x⅝	4x⅝	4x⅝	4x¾
1300	2x½	2x½	2x½	4x⅜	4x⅜	4x½	4x½	4x⅝	4x⅝	4x⅝	4x¾	4x¾
1400	2x½	2x½	4x⅜	4x⅜	4x½	4x½	4x½	4x⅝	4x⅝	4x¾	4x¾	4x⅞
1500	2x½	2x½	4x⅜	4x⅜	4x½	4x½	4x⅝	4x⅝	4x¾	4x¾	4x⅞	4x⅞
1600	2x½	2x½	4x⅜	4x⅜	4x½	4x½	4x⅝	4x¾	4x¾	4x⅞	4x⅞	4x 1
1700	2x½	4x⅜	4x⅜	4x½	4x½	4x⅝	4x⅝	4x¾	4x¾	4x⅞	4x⅞	4x 1
1800	2x½	4x⅜	4x⅜	4x½	4x½	4x⅝	4x¾	4x¾	4x⅞	4x⅞	4x 1	4x 1
1900	2x½	4x⅜	4x⅜	4x½	4x⅝	4x⅝	4x¾	4x¾	4x⅞	4x 1	4x 1	
2000	2x½	4x⅜	4x½	4x½	4x⅝	4x⅝	4x¾	4x⅞	4x⅞	4x 1		
2100	2x½	4x⅜	4x½	4x½	4x⅝	4x¾	4x¾	4x⅞	4x 1	4x 1		
2200	2x½	4x⅜	4x½	4x⅝	4x⅝	4x¾	4x⅞	4x⅞	4x 1			
2300	4x⅜	4x⅜	4x½	4x⅝	4x¾	4x¾	4x⅞	4x 1	4x 1			
2400	4x⅜	4x⅜	4x½	4x⅝	4x¾	4x⅞	4x⅞	4x 1				
2500	4x⅜	4x½	4x½	4x⅝	4x¾	4x⅞	4x 1	4x 1				

(H) FLUXES FOR SOLDERING OR WELDING

Brass	Sal Ammoniac
Copper	Sal Ammoniac
Lead	Resin and Tallow
Lead Pipes	Resin and Sweet Oil
Iron	Borax
Iron (Tinned)	Resin
Tin Pipes	Resin and Sweet Oil
Zinc	Zinc Chloride

ROUND COPPER CONDUCTORS FOR PLATING CURRENTS

B. & S. Gauge	Dia. Inches	Capacity Amperes	Resistance per 1000 ft. in ohms	Weight per 1000 ft. in lbs.
0000	.460	300	.0489	63
000	.409	245	.0617	50
00	.364	215	.0778	40
0	.324	190	.0981	31
1	.289	160	.1237	25
2	.258	135	.1560	20
3	.230	115	.1967	16
4	.204	100	.2480	13
8	.129	60	.6271	5
12	.080	30	1.586	2
16	.050	15	4.009	0.78

AMPERES REQUIRED TO PLATE ONE SQUARE FOOT OF SURFACE

(Courtesy of A. P. Munning & Co.)

METAL	AMPERES
Nickel	4
Brass	6–8
Bronze	6–8
Copper (Alkali)	6–8
Copper (Acid)	10–30
Silver	2
Zinc	1½
Gold	10

DECIMAL EQUIVALENTS

1/32	.0312	17/32	.5312
1/16	.0625	9/16	.5625
3/32	.0937	19/32	.5937
1/8	.125	5/8	.625
5/32	.1562	21/32	.6562
3/16	.1875	11/16	.6875
7/32	.2187	23/32	.7187
1/4	.250	3/4	.750
9/32	.2812	25/32	.7812
5/16	.3125	13/16	.8125
11/32	.3437	27/32	.8437
3/8	.375	7/8	.875
13/32	.4062	29/32	.9062
7/16	.4375	15/16	.9375
15/32	.4687	31/32	.9687
1/2	.500	32/32	1.000

WEIGHT OF METAL DEPOSITED PER AMPERE HOUR

(Courtesy of A. P. Munning & Co.)

(ENGLISH SYSTEM)

.0415	oz.	Copper (Acid)
.0836	oz.	Copper (Cyanide)
.0862	oz.	Gold
.136	oz.	Lead
.0377	oz.	Nickel
.119	oz.	Silver
.0782	oz.	Tin
.0428	oz.	Zinc

(METRIC SYSTEM)

1.176	grams	Copper (Acid)
2.372	grams	Copper (Cyanide)
2.444	grams	Gold
3.858	grams	Lead
1.069	grams	Nickel
3.373	grams	Silver
2.218	grams	Tin
1.213	grams	Zinc

WEIGHTS AND MEASURES

AVOIRDUPOIS WEIGHTS

16 drams	1 ounce
16 ounces	1 pound
100 pounds	1 cwt.
2000 pounds	1 short ton
2240 pounds	1 long ton

TROY WEIGHTS

24 grains	1 dwt.
20 dwts.	1 ounce
12 ounces	1 pound

Used for weighing gold, silver, and precious stones.

APOTHECARIES' WEIGHTS

20 grains	1 scruple
3 scruples	1 dram
8 drams	1 ounce
12 ounces	1 pound

METRIC WEIGHTS

10 milligrams	1 centigram
10 centigrams	1 decigram
10 decigrams	1 gram
1000 grams	1 kilogram

ENGLISH LENGTH MEASURE

12 inches	1 foot
3 feet	1 yard
5280 feet	1 mile

METRIC LENGTH MEASURE

10 millimeters	1 centimeter
10 centimeters	1 decimeter
10 decimeters	1 meter

ENGLISH SQUARE MEASURE

144 sq. inches	1 sq. foot
9 sq. feet	1 sq. yard

METRIC SQUARE MEASURE

100 sq. millimeters	1 sq. centimeter
100 sq. centimeters	1 sq. decimeter
100 sq. decimeters	1 square meter

ENGLISH CUBIC MEASURE

1728 cubic inches	1 cubic foot
27 cubic feet	1 cubic yard
40 cubic feet	1 shipping ton
231 cubic inches	1 gallon

METRIC CUBIC MEASURE

1000 cubic millimeters	1 cubic centimeter
1000 cubic centimeters	1 cubic decimeter
1000 cubic decimeters	1 cubic meter

LIQUID MEASURE

4 gills	1 pint
2 pints	1 quart
31½ gallons	1 barrel
2 barrels	1 hogshead

METRIC EQUIVALENTS

LINEAR MEASURE

1 centimeter	0.3937 inch
1 decimeter	3.937 inches
1 meter	39.37 inches
1 kilometer	0.6214 mile
1 inch	2.54 centimeters
1 foot	3.048 decimeters
1 yard	0.9144 meter
1 mile	1.6093 kilometers

SQUARE MEASURE

1 sq. centimeter	0.155 sq. inch
1 sq. decimeter	0.1076 sq. foot
1 sq. meter	1.196 sq. yards
1 sq. kilometer	0.386 sq. mile
1 sq. inch	6.452 sq. centimeters
1 sq. foot	9.290 sq. decimeters
1 sq. yard	0.8361 sq. meter
1 sq. mile	2.59 sq. kilometers

WEIGHTS

1 gram	0.0353 ounce
1 kilogram	2.2046 pounds
1 metric ton	1.1023 English tons
1 ounce	28.85 grams
1 pound	0.4536 kilogram
1 English ton	0.9072 metric ton

VOLUME

1 cu. centimeter	0.061 cu. inch
1 cu. decimeter	0.035 cu. foot
1 cu. meter	1.308 cu. yard
1 liter	1.057 quart liquid
1 cu. inch	16.39 cu. centimeters
1 cu. foot	28.32 cu. decimeters
1 cu. yard	0.765 cu. meter
1 quart liquid	0.946 liter
1 gallon	0.378 decaliter

INDEX

A

Abrasive, 143, 220
Abrasive dust, 132, 194, 203, 237
Absolute weight, 21
Accessories, automobile, 226
Acetate, lead, 25, 245
Acid, 23, 27, 83, 111, 134, 135
Acid bath, 168-169
Acid, boric, 176, 179, 189
Acid burns, 246
Acid-copper bath, 168
Acid dip, 156, 160, 161
Acid dipping, 157, 181, 186
Acid electrolyte, 169
Acid fumes, 44, 113, 151, 161
Acid, hydrochloric, 21, 25, 150, 160-161, 244
Acid, hydrocyanic, 25, 245
Acid, hydrofluoric, 150-151, 176
Acid, muriatic, 25, 132, 150, 157, 179
Acid, nitric, 24, 158, 160, 161, 245
Acid-proof paint, 85, 88
Acid-proof wall, 45
Acid, prussic, 25
Acid pump, 135
Acid resisting paint, 47
Acid stains, 45
Acid, sulphuric, 21, 25, 83, 158, 160, 168, 189, 191
Acid tank, 111
Acid vapors, 50
Acid vapors, antidates for, 246
Action, electrochemical, 26
Active area, 92
Adjusting valve, 92
Agitation, 104, 119
Agitation, air, 93
Agitation, mechanical, 93, 177
Agitation, solution, 92
Agitator, 108
Air, 46, 50, 120
Air, compressed, 119-120
Air supply, 94
Air valve, 146
Alcohol, 159
Algebra, 23
Alkali burns, 246
Alkalies, 134
Alkaline bath, 170
Alkaline solution, 151, 169
Alkalines, antidotes for, 246
Alloy, brass, 160
Alternating current, 62-63
Aluminum, 18, 21, 132, 247
Aluminum bronze, 167
Ammeter, 36, 73, 74, 235, 237
Ammeter coils, 73
Ammeter shunt, 74
Ammonia, 24, 164, 165
Ammonium chloride, 24, 164, 171, 178, 190-191
Ammonium hydroxide, 24
Ammonium sulphate, 190-191
Ammonium sulphide, 171
Ampere hour, 76
Amperehour meter, 75, 76
Amperes, 30, 33, 37
Amperes, per square foot, 251
Anion, 27–28
Anode, 27, 28, 92, 95, 104, 108, 121, 126, 165, 185
Anode, brass, 121
Anode, bronze, 167
Anode, copper, 169
Anode, corrugated, 122
Anode, curved, 101, 125

Anode, elliptic, 123
Anode, flat, 121, 123
Anode, flat plate, 122
Anode, gold, 122, 173
Anode, iron, 175
Anode, lead, 177
Anode, nickel, 177
Anode rod, 94
Anode, rolled, 185
Anode, silver, 122, 185
Anode surface, 101, 122
Anode, tin, 187
Anode, zinc, 191
Anodes, plating, 121-126
Antidotes for poisons, 244
Antimony, 18
Antimony sulphide, 165-166
Apothecaries' weight, 253
Apparatus, 62
Area, 32
Argon, 18
Armature, 66, 235-236
Armature assembly, 66
Armature coil, 62-63
Armature conductors, 66
Armature core, 63, 65
Armature shaft, 195
Armature trouble, 235
Armature winding. 232
Armature wire, 61
Arsenic, 18
Arsenic trioxide, 164
Art, 11, 16, 167
Artificial heat, 91
Artificial illumination, 48-49
Artificial light, 227
Artificial lighting, 49
Asphaltum, 47, 85, 89, 110
Asphaltum paint, 44-46, 113
Asphyxiation, 241-242
Assembly armature, 66
Assembly floor, 41
Atom, 20, 22, 26
Atomic theory, 20
Atomic weight, 21, 24, 29
Automatic conveyor, 15
Automatic machinery, 14, 102, 108, 193
Automatic moving tank, 107
Automatic plating machine, 83, 102, 110
Automatic plating tank, 105
Automatic sand blast, 145
Automobile accessories, 226
Automobile wheel rims, 109

B

Bakelite, 101
Baking soda, 25
Balance, rotative, 212
Balancing tool, 211
Ball-bearings, 68, 196
Ball burnishing barrel, 222
Ball burnishing machine, 223-224
Balls, steel, 223-224
Bar magnet, 55
Barium, 18
Baron, 18
Barrel, 98, 140, 142
Barrel, ball burnishing, 222
Barrel, burnishing, 222
Barrel, grinding, 142
Barrel hoop, 109
Barrel, metal, 140
Barrel nickel plating, 168, 180
Barrel, oblique, 101
Barrel, oblique plating, 101
Barrel, plating, 14, 42, 48, 80, 100, 126, 169, 191
Barrel, rolling, 148
Barrel, rotating, 83, 97
Barrel, sandblast tumbling, 147
Barrel, tumbling, 140, 148, 194
Barrel, zinc plating, 190
Bases, 23-24, 27
Basket, 128
Basket, dipping, 131
Basket, plating, 127-128
Basket, stoneware dipping, 132
Basket, wire, 132
Bath, cyanide, 164, 169
Bath, lye, 153
Bath, nickel plating, 183
Bath, pickle, 110

Bath, plating, 33. 91
Bath, water, 117
Battery, 27, 235. 237
Battery, chemical, 53
Battery, primary, 26, 52
Baumé, 133. 178, 183
Bearing friction, 237
Bearing trouble. 237
Bearings, 44. 68. 195-196
Bearings, ball. 68. 196
Bearings, bronze. 68
Bearings, non-frictional, 68
Bearings, self-oiling, 195
Bee's wax, 172
Bell metal. 167
Bell, signal, 77
Belt, link, 107
Belt strapping, 199
Belt velocity, 241
Belt-driven lathe, 195
Belting. 70
Belts, 239
Bench, scouring, 153
Bicarbonate, sodium, 25
Bismuth. 18
Bisulphate, sodium, 166
Black nickeling, 179
Blistering, 183
Blower, 149
Blower system, 204
Blue stone, 25
Blue vitriol, 25
Board, cleaning, 42
Board, scouring, 42, 114, 155
Bobbin, 72-73
Bobbin winding, 73
Boiler, 117
Bolt, 88
Boric acid, 176, 179, 189
Box, hot sawdust, 120
Boxwood sawdust, 119
Branch, 36-37
Brass, 14, 108, 156, 163, 168, 217, 247
Brass alloy, 160
Brass anode, 121
Brass coloring, 165
Brass plating, 163-164
Brass plating solution, 163
Brass tank, 42
Brass tube, 95
Bright dipping, 111, 159
Broken circuit, 236
Bromine, 18
Bronze, 166, 171
Bronze aluminum, 167
Bronze anodes, 167
Bronze bearings, 68
Bronze plating, 167
Bronze plating solution, 166
Brush, cleaning, 157
Brush contact, 234
Brush, cotton potash, 156
Brush, glue, 212
Brush, goblet-shaped, 156
Brush, hand, 154
Brush holder, 59, 67
Brush rigging, 66
Brush, rotary, 155
Brush, rotating, 155
Brush, scratch, 153
Brush, soft hair, 159
Brush, woven wire, 68
Brushes, composition, 67
Brushes, dynamo, 61, 64, 67, 233, 235
Bubble, air, 94
Bubbles, gas, 92, 103, 183
Buff leather wheel, 218
Buff, stubless, 218
Buffing, 137, 194, 215
Buffing composition, 218
Buffing lathe, 197
Buffing speed, 221-222
Buffing wheel, 215
Buffs, 170, 215
Buffs, speed of, 221-222
Buffs, woolen cloth, 216-217
Building up, generator, 232
Bullneck polishing wheel, 208
Bureau of Standards, 14
Burnisher, steel ball, 15
Burnishing barrel, 222
Burnishing, steel ball, 143
Burns, 246
Busbar, 80, 94
Business competition, 40
Business expansion, 41, 69

C

Cadmium, 18
Cæsium 18
Calcium, 18
Calibration, 74
Candle power, 49-50
Canton flannel, 215
Canvas, 207-208
Canvas polishing wheel, 207
Canvas wheel, 207, 213
Capacity, 68
Carat, 172
Carbon, 18, 26, 33, 67
Carbonate, copper, 171
Carbonate, lead, 25, 176
Carbonate, potassium, 25
Carbonate, sodium, 25, 164, 165, 179, 192
Carboy 135-136
Carboy inclinator, 136
Carpenter's level, 90
Cast anode, 180, 187, 191
Cast iron, 63, 213
Casting, iron, 151, 192
Casting, plate, 121
Castings 97, 130, 140, 147, 151, 201
Catalytic agents, 168-169, 184, 189
Cathode, 26, 28, 62, 103, 108, 124, 152, 192
Cathode rod, 49, 95, 126
Cathode surface, 102
Cation, 26-28
Caustic potash, 165, 174
Caustic soda, 152, 153, 164, 170, 187, 190, 192
Ceiling, 44
Centigrade, 32, 247
Cerium, 18
Chain, conveyor, 104-107
Chains, 109
Charging, the tumbler, 142
Cheese cloth, 90
Chemical action, 17
Chemical affinity, 17
Chemical battery, 53
Chemical equation, 16, 23
Chemical equivalents, 28-29
Chemical symbols, 18
Chemical transformation, 24
Chemist, 11
Chemistry, 16, 25, 28
Chemistry, electro-, 16
Chloride, ammonium, 24, 164, 171, 178, 191
Chloride, ferric, 25
Chloride, gold, 172-173
Chloride, iron, 25
Chloride, lead, 24
Chloride, mercuric, 25
Chloride, nickel, 24
Chloride, nickel ammonium, 24
Chloride, potassium, 24
Chloride, silver, 158, 184-185
Chloride, sodium, 25
Chloride, stannous, 25
Chloride, tin, 25, 166, 187
Chlorine, 17, 19, 21, 24
Chromium, 19
Circuit, 34–38, 61
Circuit, broken, 236
Circuit, field, 72, 232
Circuit, hydraulic, 29-30
Circuit, line, 59
Circuit, open, 235
Circuit, parallel, 34, 78
Circuit, series, 34
Circuit, short, 234-236
Circuit, tank, 92
Cleaning board, 42
Cleaning, electrolytic, 151-152
Cleansing, 139
Cloth disc, 215
Clothing, 137
Coal, 117
Cobalt, 19
Coil, 66, 91, 183
Coil capacity, 111
Coil, cooling, 30
Coil, field, 59-60
Coil, steam, 92, 111-119, 152, 153, 227
Coils, ammeter, 73
Coils, armature, 62-63
Cold galvanizing, 188
Cold pickle tank, 111

Cold pickling, 110
Collector ring, 97
Colored lacquer, 230
Coloring, 165-171
Coloring, brass, 165
Coloring, copper, 171
Coloring, iridescent, 230
Coloring solution, 165
Columbium, 19
Combinations, 17
Combining weights, 22
Commercial practice, 56
Commercial work, 40
Common salt, 25
Commutation, 62
Commutator, 44
Commutator, 63-65, 71, 233
Commutator bar, 234-236
Commutator segment, 63
Commutator, sparking, 233
Comparison of thermometers, 247
Components, 26
Composition brushes, 67
Composition, buffing, 218
Composition, cutting down, 220
Composition, finishing, 220
Compound, 57
Compound generator, 57
Compounds, 17–21
Compress wheel, 209
Compressed air, 119-120
Compressed air agitation, 93
Compressed air supply, 42
Compressor, 120
Concrete base, 45
Conductance, 36
Conductivity, of metals, 247
Conductor, 17-29, 61, 108
Conductor bar, 107-108
Conductor copper, 44, 69
Conductor, sizes of, 247-249
Conductors, armature, 66
Conductors for plating currents, 250
Constant, 33-35
Constant voltage, 65
Contact, brush, 234
Conversion factor, 39, 71
Conveyor, automatic, 15
Conveyor chain, 104-107
Cooling coils, 30
Copper, 13-28, 30-32, 77, 121, 156, 189, 217
Copper alloy, 156, 160, 166
Copper anode, 169
Copper bath, 181
Copper carbonate, 171
Copper coloring, 171
Copper conductor, 44, 69
Copper cyanide, 153, 164, 168, 170
Copper deposit, 153
Copper deposition, 169
Copper dust, 234
Copper flashing, 152
Copper hook, 107, 128
Copper plating, 156, 167, 177
Copper plating solutions, 167
Copper rod, 95, 128
Copper segments, 66
Copper striking, 152, 170
Copper strip, 66, 108
Copper sulphate, 24-28, 168
Copper tank, 42
Copper tube, 95
Copper wire, 126
Copperas, 25
Core, 236
Core, armature, 63-65
Core, iron, 63
Corrosion, 104
Corrosive sublimate, 25
Corrugated anode, 122
Cost, 14, 70
Cost, copper conductors, 44
Cost, of materials, 76
Cotton potash brush, 156
Cotton wick buff wheel, 217–218
Coulomb, 37
Counter shaft, 71, 195, 238
Counter shaft, speed of, 239
Counter-sinking, 41
Coupling, 91
Cover plate, 101
Cream of tartar, 171
Crocus, 219, 220
Cross-section, 32-33

Crystallization, 183
Cup, oil, 196
Cupric oxide, 24
Current, 26-37, 55, 61-73, 90
Current, alternating, 62-63
Current density, 152
Current, direct, 13
Current direction, 64
Current direction, reversal of, 233
Current, eddy, 63
Current, electric, 26-33, 55, 92
Current, field, 58
Current flow, 28-34, 62, 72
Current, line, 57-58, 73-74
Current, plating, 58, 95
Current pressure, 62, 74, 80, 176, 188, 191
Current regulation, 57
Current, reverse, 158
Current strength, 33
Current supply, 53, 231
Current, uni-direction, 62
Current value, 33, 36, 37, 62
Curved anode, 101, 125
Customers, 40
Cut, 13
Cutlery, 13, 163
Cutting down composition, 220
Cutting speed, 218
Cutting surface, 210
Cyanide bath, 164, 169
Cyanide, copper, 153, 164, 168, 170
Cyanide electrolyte, 170
Cyanide, potassium, 24, 156, 158, 172, 185, 186
Cyanide, sodium, 153, 164, 170, 184, 192
Cyanide solution, 83-85
Cyanide, zinc, 24, 164, 190
Cycle, 62
Cylinder, 100-101
Cypress boards, 114

D

Dalton, 22
D'Arsonval, 73
D'Arsonval galvanometer, 73
Daylight, 48-49
Death bombs, 14
Decimal equivalents, 251
Decompose, 29
Decomposition, 26
Deflection, 74
Denim, 215
Departments, 41
Deposit, 28, 93, 98, 105, 127, 152, 164, 185
Deposit, copper, 153
Deposition, 163, 191
Deposition, copper, 169
Deposition, electro-, 11, 27, 72, 162
Deposition, gold, 173
Deposition, iron, 176
Deposition, nickel, 181
Deposition, silver, 163
Development, 14
Dial, 77
Diameter of pulley, 240
Dielectric, 65
Difference of potential, 32-34, 236
Dioxide, sulphur, 24
Dip, lye, 116
Dip, potassium cyanide, 156
Dipping, acid, 111
Dipping basket, 131
Dipping, bright, 111, 159
Dipping lye, 153
Dipping tank, 112
Dipping vats, 48
Dips, 42
Dips, acid, 113
Direct current, 73
Direct-current generator, 71
Direct-current machine, 71
Disc wheel, 206
Discoloration, 160
Disintegration, 122
Double-voltage generator, 80
Drain, 44, 45, 46
Drain tray, 229
Drainage, floor, 44
Drawn metal, 130
Drawn steel work, 110, 212

Dresser, emery wheel, 211
Drilling, 41
Drill press, 41
Drive shaft, 238
Driving motor, 48, 70
Driving unit, 39, 69, 71
Drop forging, 110, 212
Drop in potential, 44
Drop in pressure, 31
Drum, 61-65
Drying, 182
Drying apparatus, 182
Drying oven, 108, 117, 134, 226
Ducts, ventilating, 63
Dust, 44, 149
Dust, abrasive, 132, 194, 203, 237
Dust collector hood, 203
Dust, copper, 234
Dust, emery, 196
Dyes, 230
Dynamo, 57, 64, 80
Dynamo, design, 65

E

Earthenware tanks, 83
Eddy current, 63
Efficiency, 41, 82, 107, 204
Electric circuit, 29, 30, 32, 33, 46
Electric contact, 72
Electric current, 26, 30, 55, 92
Electric energy, 32, 38
Electric light, 49, 77
Electric motor, 70
Electric power, 38, 70
Electric shock, 241-242
Electricity, 16-17, 29, 37
Electrical charges, negative, 26
Electrical charges, positive, 26
Electrical fixtures, 226
Electrical losses, 71
Electrical machinery, 167
Electrical measurement, 30
Electrical resistance, 32-33
Electrical units, 17
Electro-bar magnet, 55
Electro-chemical action, 26
Electro-chemistry, 16
Electro-deposit, 121, 139
Electro-deposition, 11, 27, 72, 162
Electro-galvanizing, 13, 106, 188, 193
Electrodes, 26, 27, 28
Electrolysis, 11, 26
Electrolyte, 27, 91, 100, 117, 151, 164
Electrolyte cleaning, 151, 152
Electrolyte, cyanide, 170
Electrolyte, gold, 85
Electrolyte, nickel, 133
Electrolytic solution, 119
Electro-magnet, 54, 55
Electro-motive force, 26, 33, 60, 80
Electroplater, 14, 33, 47, 70
Electroplating, 11
Electroplating business, 40
Electroplating industry, 40
Electro-positive, 12, 167, 181, 189
Electrotypers' varnish, 159
Electrotyping, 11-13, 159
Elementary principles, 54
Elements, 17, 18, 20, 28
Elements, tabulation of, 18
Elliptic anodes, 123
Emery, 203, 212, 220
Emery application, 212
Emery dust, 196
Emery trough, 215
Emery wheel, 140
Emery wheel dresser, 211
E. M. F. curve, 62-64
Employees, 40, 44
Enamel-lined containers, 85
Enamel lining, 85
Enamelled iron tank, 85
Engine, 38, 69
Engine drive, 70
English cubic measure, 254
English length measure, 253
English square measure, 253
Equation, 24, 33, 36
Equation, chemical, 16, 23

Equipment, 40, 49, 195
Equipment, ventilating, 133
Equivalent, 28-29
Equivalent weight, 29
Equivalents, decimal, 251
Erbium, 19
Europium, 19
Exhaust, 51
Experimental work, 53
Explosive shells, 14
External shunt, 74
Eye strain, 41

F

Factor, conversion, 39, 71
Factory, 41, 120
Factory department, 41
Factory, output, 41
Fahrenheit, 247
Fall of potential, 31
Fall of pressure, 31
Fan, ventilating, 47, 205
Fans, motor-driven, 42
Fans, power-driven, 47
Faraday, 28-30
Faraday's laws, 28
Faucet, 96
Felt, 207-208
Ferric chloride, 25
Ferric oxide, 25
Ferric sulphate, 22
Ferrous ammonium sulphate, 175
Field circuit, 72, 232
Field coils, 59-60
Field current, 58
Field excitation, 57, 60, 72, 232
Field, generator, 233
Field magnet, 55, 58, 60
Field magnetic, 61
Field pole, 55, 61, 232
Field rheostat, 232
Field troubles, 236
Field winding, 58, 236
Filter mask, 132
Fining, 212
Finishing composition, 220
Fire-proof material, 72
Flanges, 65
Flannel, Canton, 215
Flashing, 170
Flashing, copper, 152
Flat anode, 121, 123
Flat plate anode, 122
Floor, 50
Floor area, 41
Floor construction, 44-45
Floor drainage, 44
Floor plan, 42-43
Floor plan-polishing room, 194
Floor space, 107
Floor surface, 45
Flowers, metallized, 158
Fluorine, 19
Flux, magnetic, 61
Foot lever, 146
Foot-pounds, 38
Force, electro-motive, 26, 33, 60, 80
Force, lines of, 61
Foreign substances, 150
Forging, drop, 110, 212
Forgings, 147
Foundation, 45, 69
Foundry work, 110
Four-pole generator, 55
Framework, 46
Fresh air, 42
Friction, bearing, 237
Frictional losses, 70
Fumes, 42, 47, 50, 69, 176
Fumes, acid, 44, 113, 151, 161
Fumes, poisonous, 42

G

Gadolium, 19
Gages, 31
Gages, pressure, 31
Gallium, 19
Gallon, 30
Galvanizing, 193
Galvanizing, cold, 188
Galvanizing, electro, 13, 106, 188, 189, 193

Galvanizing, hot, 188
Galvanizing solution, 191
Galvanometer, D'Arsonval, 73
Gas, 17, 24, 118, 170, 193
Gas bubbles, 92, 103, 183
Gelatine, 169
Generator, 27, 44, 53, 137, 231, 235
Generator armature, 63, 71
Generator capacity, 39, 71
Generator, compound, 57
Generator, direct-current, 71
Generator, double-voltage, 80
Generator field, 233
Generator field rheostat, 72
Generator, four pole, 55
Generator frame, 59
Generator location, 42
Generator output, 71
Generator, plating, 54, 137
Generator, self-excited, 232
Generator, separately excited, 57-60
Generator, series, 57-58-60
Generator, shunt, 57-58-60
Generator speed, 71
Generator, speed of, 72
Generator, steam, 116
Generator voltage regulation, 72
German silver, 167, 247
Germanium, 19
Gild, 173
Gilding, 174
Glass, 143
Glass shield, 201
Glauber's salts, 25
Glucinum, 19
Glucose, 169, 184
Glue, 169, 177, 184, 205, 213, 214
Glue brush, 212
Glue heater, 213-214
Goblet-shaped brush, 156
Gold, 13, 163, 172, 184, 217, 247
Gold anode, 122, 173
Gold chloride, 172-173
Gold deposition, 173
Gold electrolyte, 85
Gold plating, 13
Gold plating solution, 172
Grain, 173
Grape sugar, 189
Graphite, 159
Gravel, 143
Grease, 138, 152, 181, 218, 226
Grinder, 202
Grinder, portable, 201
Grinder, surface, 202
Grinding, 194, 203
Grinding barrel, 142
Grinding lathe, 200
Grinding wheel, 201-204
Ground, 236
Guards, 200
Gun metal, 167

H

Hand brush, 154
Hand hole, 146
Hanger, 238
Hardware, 12, 163, 226
Health, 42, 44, 47, 203
Heat, 17, 32, 72
Heat, artificial, 91
Heater, glue, 213-214
Heater, steam coil, 91
Heating, 236
Heating problem, 50
Heating units, 50
Helium, 19
Hood, ventilating, 42, 112, 176, 229
Hoods, 47-48, 204
Horizontal tumbler, 140
Horse-power, 38-39, 71
Horseshoe magnet, 54
Hot galvanizing, 188
Hot solutions, 134
Hydraulic circuit, 29-30
Hydrochloric acid, 21, 150, 160, 244
Hydrocyanic acid, 25, 245
Hydrofluoric acid, 150-151, 176

Hydrogen, 17-21, 29, 152, 175, 183
Hydrometer, 133-134, 178, 182
Hydrostatic pressure, 30
Hydrosulphite, sodium, 187
Hydroxide, ammonium, 24
Hydroxide, sodium, 23

I

Illumination, 50
Illumination, artificial, 48-49
Impregnate, 44
Impregnating compound, 69
Inclinator, carboy, 136
Indicator, 137
Indicator, speed, 71, 137, 232
Indium, 19
Industrial plant, 93
Industry, 13-14
Insects, 158
Inspection, 98
Instrument, 74
Instruments, scientific, 226
Insulating joint, 91, 93
Insulation, 44, 72
Insulator, 94
Internal resistance, 75
Iodine, 19
Ions, 26, 62
Iridescent coloring, 230
Iridium, 19
Iron, 12, 17, 32, 158, 170, 175, 178, 247
Iron anodes, 175
Iron, cast, 63, 212
Iron casting, 151, 192
Iron chloride, 25
Iron, core, 63
Iron deposition, 176
Iron, malleable, 213
Iron, oxide, 25, 219
Iron plates, 88
Iron plating solution, 175
Iron rod, 55
Iron solutions, 175
Iron washers, 88
Iron yolk, 56

J

Jacketed kettle, 113
Jacketed tank, 113
Jacobi, 11
Jar, stoneware, 161
Jewelry, 13, 159, 163, 172
Joint insulating, 91-93
Joule, 37-38

K

Kalium, 18
Keep-sakes, 159
Kettle, jacketed, 113
Kilowatt, 37-39
Kilowatt hour, 38
Krypton, 19

L

Labor, 102
Labor-saving machinery, 15
Laboratory, 12
Lacquer, 160, 226
Lacquer application, 227
Lacquer, colored, 230
Lacquer room, 134, 226
Lacquer spray, 119
Lacquering, 108, 225, 226
Laminæ, 63
Lamps, 49
Lanthanum, 19
Lathe, 155
Lathe, belt driven, 195
Lathe, buffing, 197
Lathe, grinding, 200
Lathe head, 196
Lathe, motor driven, 195
Lathe, overhanging, 199
Lathe, overhanging polishing, 198
Lathe, polishing, 206
Law of multiple proportions, 22
Lead, 14, 74, 176, 247
Lead acetate, 25, 245

Lead anodes, 177
Lead carbonate, 25, 176
Lead chloride, 24
Lead oxide, 23
Lead peroxide, 23-24
Lead pipe, 91-93, 110
Lead plating, 177
Lead plating solution, 176
Lead sesquioxide, 23
Lead sheeting, 89
Lead suboxide, 23
Lead; sugar of, 25
Lead, white, 25
Leakage, 85
Leaks, in floor, 41
Leaks, in tank, 87
Leather, 206-207
Leather wheels, 216
Leaves, 159
Length, 32-33
Light, 50
Light, artificial, 227
Light, electric, 77
Lighting, artificial, 49
Lighting, natural, 41
Lightning, 233
Lime, 218
Lime compositions, 219
Lineal measure, 254
Line circuit, 59
Line current, 57, 73
Line pressure, 72
Line shaft, 69-70, 195
Line shaft losses, 120
Line voltage 35
Lines of force, 61
Lining, 85-90
Lining material, 90
Link belt, 107
Liquid measure, 254
Lithium, 19
Litmus, 134
Litmus paper, 134, 183
Loss, mechanical, 71
Losses, lineshaft, 120
Low voltage, 232
Lubrication, 68
Lumber, 86
Lump pumice, 219
Lye, 85, 153
Lye bath, 153
Lye dip, 116
Lye dipping, 153

M

Machine, 53, 60, 70
Machinery, 14
Machinery, automatic, 14, 102, 108, 193
Machinery operations, 41
Magazines, 16
Magnesium, 19
Magnet, 73
Magnet, bar 55
Magnet, electro, 54-55
Magnet, electro-bar, 55
Magnet, field, 55, 58, 60
Magnet, horseshoe, 54
Magnet, permanent, 73
Magnetic area, 60
Magnetic characteristic, 63
Magnetic field, 61
Magnetic flux, 61
Magnetic properties, 54
Magnetism, residual, 232-233
Malleable iron, 213
Management, 40
Manganese, 19
Manufacturers, 14, 68
Material, 32-33
Measure, cubic, 254
Measure, length, 253
Measure, lineal, 254
Measure, liquid, 254
Measure, metric cubic, 254
Measure, metric length, 253
Measure, metric square, 254
Measure, square, 253
Measures, 253-254
Mechanical agitations, 93, 177
Mechanical loss, 71
Mechanical plating, 191, 193
Mechanical plating tank, 109
Mechanism, 77
Men, 42

Mercuric chloride, 25
Mercury, 19, 32, 186, 247
Mercury salts, 245
Metal barrel, 140
Metal drying apparatus, 182, 192
Metal, per ampere hour, 251
Metal ribbon, 72
Metal tubing, 110
Metal wire, 108
Metallic ring, 61
Metallic strips, 59
Metallized flowers, 158
Metals, 26, 33
Metals, precious, 13, 23
Meter, 32, 74, 77
Meter, ampere hour, 75–76
Metric cubic measure, 254
Metric equivalents, 254
Metric length measure, 253
Metric square measure, 254
Metric weights, 253
Mica, 69, 236
Mineral oil, 237
Minute, 121
Moisture, 226-227
Molecular composition, 22
Molecule, 21, 26, 105
Molybdenum, 19
Motor, 38, 70, 137, 195
Motor capacity, 70-71
Motor drive, 70
Motor driven lathe, 195
Motor, driving, 48, 70-71
Mould, 13
Moving tank, automatic, 107
Multiple, 34, 37
Multiple proportion, 22
Munitions, 14
Muriatic acid, 25, 132, 150, 155-179
Muslin, 215
Muslin, unbleached, 217

N

Name plate, 71, 137, 232
Natural ventilation, 47
Negative, 64
Neon, 19
Nickel, 12, 19, 163, 167, 241
Nickel ammonium sulphate, 178-179
Nickel anode, 177
Nickel chloride, 24
Nickel deposition, 181
Nickel electrolyte, 133
Nickel plating, 121, 175, 180
Nickel plating bath, 183
Nickel salt, 123, 134, 179, 183
Nickel solution, 121
Nickel sulphate, 178-179
Nickel tank, 42
Nitrate, potassium, 25
Nitrate, silver, 18, 24, 30, 37
Nitrate, sodium, 24, 158
Nitric acid, 24, 158, 160, 245
Nitrogen, 17, 18, 19
Noises, 237
Non-acid solutions, 85
Non-conductor, 158, 169
Non-corrosive metal, 12
Non-frictional bearings, 68
North pole, 55
Novelties, 159
Nuts, 42, 88

O

Oblique plating barrel, 101
Oblique tumbler, 140
Office, 69
Ohm, 32-33
Ohm's law, 33
Oil hole, 196
Oil, lubricating, 68
Oil, mineral, 237
Oil of vitriol, 25
Oil, polishing, 212
Oil rings, 68
Oil well, 237
Open circuit, 235
Operator, 104, 194, 227
Osmium, 19
Output, 54, 71

Oven, 42, 108, 117
Oven, drying, 108, 117, 134, 226
Overflow, 112
Overflow pipe, 113
Overhanging lathe, 199
Overhanging polishing lathe, 198
Overhead expense, 54
Overheat, 63
Overloading, 235
Oxide, 155, 215
Oxide, ferric, 25
Oxide, iron, 25, 219
Oxide, lead, 23
Oxide, silver, 24
Oxygen, 17-29

P

Packing, 41
Paint, 12, 90
Paint, acid proof, 85-88
Paint, acid resisting, 47
Paint, asphaltum, 44, 46, 113
Palladium, 19
Paper, litmus, 134, 183
Paper, roofing, 44, 46
Paper wheel, 207
Parallel, 34, 37, 57
Parallel circuits, 34, 78
Particles, 20-21, 26
Peeling, 183
Permanent magnet, 73
Peroxide, lead, 23-24
Phenomenon, 17
Phosphorus, 19
Pickle bath, 110
Pickles, 117, 151
Pickling, 108, 110, 143, 181
Pickling, cold, 110
Pickling tank, 46, 112
Pipe, 30, 93
Pipe, lead, 91, 93, 110
Pipe, overflow, 113
Pipe, sheet metal, 47
Pipe, water, 30, 46
Piping system, 92
Plant, industrial, 93
Plate castings, 121
Plater, 16, 42, 49, 68, 72
Platform, 44
Plating anodes, 121-126
Plating barrel, 14, 42, 48, 100, 126
Plating, barrel nickel, 168, 180
Plating, barrel zinc, 190
Plating basket, 127-128
Plating bath, 33, 91
Plating, brass, 163, 164
Plating, bronze, 167
Plating, copper, 156, 167, 177
Plating current, 58, 95
Plating currents, conductors for, 250
Plating division, 41
Plating equipment, 53
Plating generator, 54, 137
Plating hooks, 128
Plating, lead, 177
Plating, mechanical, 191
Plating, nickel, 121, 175, 178, 180, 183
Plating operation, 41, 54
Plating process, 98
Plating racks, 128-129-130
Plating room, 15, 41, 69, 120
Plating, silver, 13, 42
Plating solutions, 90
Plating tank, 42
Plating tank, automatic, 105
Plating tanks, 94
Plating, tin, 187
Plating work, 33, 57, 67, 71
Plating, zinc, 13, 193
Platinum, 19, 173
Plumbago, 159
Plumbing, 96
Pointer, 77
Pointer, voltmeter, 61
Poisonous fumes, 112, 132
Poisonous vapors, 242
Poisons, antidotes for, 244
Polarity, 55
Pole, south, 61
Poles, 55, 61-62, 67
Polishing, 153, 206, 207
Polishing head, 200

Polishing lathe, 206
Polishing operation, 41
Polishing room, 43, 194-195-196
Polishing wheel, 204, 215
Porcelain, 158
Portable grinder, 201
Positive plate, 92
Positive value, 64
Potash, 85
Potash, caustic, 165, 174
Potash solution, 110
Potassium, 18-19
Potassium carbonate, 25
Potassium chloride, 24
Potassium cyanide, 24, 158, 172, 185
Potassium cyanide, antidote for, 245
Potassium cyanide dip, 156
Potassium hydroxide, antidote for, 245
Potassium nitrate, 25
Potassium sulphate, 171
Potassium sulphide, 171
Potential, 30, 69
Potential difference, 31-33, 75
Potential, difference of, 32, 34, 236
Potential, drop in, 44
Potential, fall of, 31
Power, 37-38, 70, 195
Power plant, 196
Power, transmission of, 238
Praseodynum, 19
Precious metals, 13
Press, 203
Press, drill, 41
Press, punch, 41
Pressure, 37
Pressure, difference, 30
Pressure drop, 31
Pressure, fall of, 31
Pressure gages, 31
Pressure, hydrostatic, 30
Pressure, line, 72
Primary battery, 26, 52
Printing, 13
Production, 15, 41, 82, 102, 115, 213
Protective coating, 12
Protective agent, 12
Prussic acid, 25
Pulley, 71, 196, 201, 238
Pulley, diameter of, 240
Pulverizing, 26
Pumice, 143, 154, 174, 218, 220
Pump, acid, 135
Punched parts, 41
Punchings, 97
Punch press, 41
Punch shop, 41

R

Rack, for drying, 227
Rack, for plating, 104, 107, 130
Radiator, 227
Radium, 19
Reaction, 23
Reciprocal, 36
Regulating valve, 92–94
Regulation, current, 57
Regulation, generator voltage, 72
Relative density, 133
Relative weight, 21
Research work, 13
Residual magnetism, 232-233
Resilience, 207
Resistance, 30-32, 74, 78, 90
Resistance electrical, 32-33
Resistance factors, 32
Resistance, internal, 75
Resistance units, 34, 35, 37
Resistances in parallel, 35
Respirator, 132
Resuscitation, 243-244
Reversal of current direction, 233
Reverse current, 158
Rheostat, 33, 80
Rheostat, field, 232
Rheostat, generator field, 72
Rheostat, tank, 78-80
Rhodium, 19
Riddle, 118

Ring, metallic, 61
Ring, oil, 68
Ring, slip, 64
Rinsing, 151
Rinsing tank, 113-114
Rinsing vat, 112
Rod, copper, 95, 128
Rolled anode, 185
Roller, 212
Rolling barrel, 148
Roofing paper, 44, 46
Roof ventilator, 42, 204
Room, lacquer, 134, 226
Room, plating, 15, 41, 45, 69, 120
Room, polishing, 43, 194, 195
Room, sand blast, 145
Room, store, 69
Rotary brush, 155
Rotary plating tank, 100
Rotating barrel, 83, 97
Rotating plating tank, 100
Rotating table sand blast, 148-149
Rotative balance, 212
Rotten stone, 219
Rough, 218–219
Roughing, 212
Round-section anode, 124
Round wire, 32
Routing, 41
Rubber apron, 138
Rubber glove, 138
Rubidium, 19
Rules for speed, 239
Rust, 12, 128, 139, 151, 163
Ruthenium, 19

S

Sal ammoniac, 24, 179
Sal soda, 25
Salt, mercury, 245
Salt, nickel, 123, 134, 179, 180
Salt, table, 21, 160
Salt, tartar, 25
Saltpetre, 25, 158
Salts, 23, 24, 27
Salts, Glauber's, 25
Samarium, 19
Sand, 143
Sand blast apparatus, 194
Sand blast machine, 119, 149, 150
Sand blast room, 145
Sand blast rotating table, 148-149
Sand blast sand, 150
Sand blast, single hose, 144
Sand blast tumbling barrel, 147
Sand blasting, 110, 145, 150, 174, 193
Sand container, 143
Sandpaper, 205
Sand, sandblast, 150
Sand, silica, 150
Sawdust, 42, 142
Sawdust box, 117-118
Sawdust, boxwood, 119
Scalds, 246
Scale, coating of, 110, 139
Scale divisions, 73
Scandium, 19
Scientific instruments, 226
Scouring, 110, 113, 154, 157, 182
Scouring bench, 153
Scouring boards, 42, 114, 155
Scouring tank, 113
Scratch brush, 153
Scratch brushing, 153
Screws, 42
Scrubbing, 113, 154
Second, 37
Segment, commutator, 63
Segment, copper, 66
Segments, 65, 234
Selenium, 19
Self-excited generator, 232
Self-oiling bearings, 195
Separately excited shunt generator, 57-60
Series, 57-59
Series circuits, 34
Series connected, 72
Series generator, 57-58-60
Service, 53

Sesquioxide, lead, 23
Shadows, 50
Shaft, 61, 68, 238
Shaft, armature, 195
Shaft, counter, 71, 195, 238
Shaft drive, 238
Shafting, 137
Shaft, line, 69, 70, 195
Sheepskin polishing wheel, 208-210
Sheeting, 215
Sheeting, lead, 89
Sheet iron, 47
Sheet metal pipes, 47
Shellac, 159
Shipping, 41
Shoes, 138, 159
Shop, 70
Short circuits, 234, 235, 236
Shunt, 57
Shunt, ammeter, 74
Shunt, external, 74
Shunt generator, 57-58, 60
Shunt winding, 58
Shunt wound, 71
Sifting device, 225
Silica sand, 150
Silicon, 19
Silver, 13, 17, 30, 37, 77, 158, 167, 185, 217
Silver anode, 122, 185
Silver chloride, 158, 184-185
Silver, conductivity of, 247
Silver deposition, 163
Silver, German, 167, 247
Silver nitrate, 18, 24, 30, 37
Silver nitrate, antidote for, 245
Silver oxide, 24
Silver plating, 13, 42
Silver plating solutions, 184
Silver sulphide, 184
Single hose sand blast, 144
Slinging wire, 126, 153
Slip ring, 64
Slot, 66
Slot wedge, 66
Smoke, 184
Soda, baking, 25
Soda, caustic, 152, 164, 170, 187
Soda, sulpho-cyanide of, 179
Sodium, 20-21
Sodium bicarbonate, 25
Sodium bisulphate, 166
Sodium carbonate, 25, 164, 179, 192
Sodium chloride, 25
Sodium cyanide, 153, 164, 166, 170, 184, 187, 190
Sodium hydroxide, 23
Sodium hydroxide, antidote for, 245
Sodium hyposulphite, 181
Sodium nitrate, 24, 158
Sodium sulphate, 25
Solenoid, 55
Solids, 26
Solution agitation, 92
Solution, brass plating, 163
Solution, bronze plating, 166
Solution, coloring, 165
Solution, copper plating, 167
Solution, cyanide, 83-85
Solution, electrolytic, 119
Solution, galvanizing, 191
Solution, gold plating, 172
Solution, hot, 134
Solution, iron, 175
Solution, lead plating, 176
Solution, non-acid, 85
Solution, plating, 90
Solution, potash, 110
Solutions, 26
Solutions, alkaline, 151, 169
Solutions, nickel, 121
Solutions, silver plating, 184
Solutions, tin plating, 187
Solutions, warm, 91
Solutions, zinc plating, 189
South pole, 61
Sparking, 234
Sparking commutator, 233
Specific gravity, 133
Speed, buffing, 221-222
Speed, cutting, 218
Speed, generator, 71, 72
Speed indicator, 71, 137, 232
Speed of buffs, 221-222
Speed of counter shafts, 239

Speed of machines, 240
Speed of rotation, 102
Speed, rules for, 239
Spencer, 11
Spider, 63
Spotting, 171
Sprayer, 228
Spraying, lacquer, 227
Spray, lacquer, 119
Spray pistol, 228
Spray system, 227
Square measure, 254
Stains, acid, 45
Stains, water, 45
Standards, bureau of, 14
Stannous chloride, 25
Stannum, 18
Stator, 57
Steam, 46, 91, 117
Steam coil, 92, 111, 152, 227
Steam coil heater, 91
Steam generator, 116
Steam supply, 42, 117
Steel, 158, 160, 175, 181, 190
Steel Ball Burnisher, 15, 145
Steel balls, 223-224
Steel, boiler, 85
Steel rod, 88
Steel tank, 83
Steel vat, 85
Still tank, 15, 83, 102, 164
Still tank zinc plating, 189
Stone, blue, 25
Stoneware dipping basket, 132
Stoneware jars, 161
Stoneware vat, 83
Stop-cock, 30-31
Storage, 41, 194
Store room, 41, 69
Stove, 50, 227
Strike, 185
Strike, silver, 185
Striking, 152
Striking, copper, 152, 170
Strip, 57
Strip copper, 108
Stripping, 157
Strontium, 20
Stubless buff, 218
Student, 16
Sublimate, corrosive, 25
Suboxide, lead, 23
Substance, 17, 20, 32
Sugar, 22
Sugar of lead, 25
Sulphate, ammonium, 190-191
Sulphate, copper, 24, 25, 28, 168
Sulphate, ferric, 22
Sulphate, ferrous ammonium, 175
Sulphate, nickel, 178-179
Sulphate, nickel ammonium, 178–179
Sulphate, potassium, 171
Sulphate, sodium, 25
Sulphate, zinc, 23, 179, 189, 191
Sulphide, ammonium, 171
Sulphide, antimony, 165-166
Sulphide, silver, 184
Sulphite, potassium, 171
Sulpho-cyanide of soda, 179
Sulphur, 20, 22, 184
Sulphur dioxide, 24
Sulphuric acid, 21, 83, 158, 160, 189, 191
Sulphuric acid, antidote for, 244
Supply wires, 80
Surface grinder, 202
Switch, 30, 75, 80
Symbol, 21-23
Symbols, chemical, 18
System, 21, 31

T

Table salt, 21, 160
Tableware, 13, 163
Tabulation of elements, 18
Tallow, 212-213, 218
Tank, 83, 88, 93, 104
Tank, acid, 111
Tank capacity, 82
Tank circuit, 92
Tank, cold pickle, 111
Tank construction, 86
Tank, copper, 42
Tank, dipping, 112

Tank, earthenware, 83
Tank, enamelled iron, 85
Tank, jacketed, 113
Tank location, 49
Tank, mechanical plating, 109
Tank, nickel, 42
Tank, pickling, 46, 112
Tank, plating, 42, 94
Tank rheostat, 78, 80
Tank, rinsing, 113-114
Tank rods, 44, 94
Tank, rotary plating, 100
Tank, rotating plating, 100
Tank, scouring, 113
Tank, steel, 83
Tank, welded, 85
Tank, wooden, 85
Tank, wooden plating, 88-89
Tank, zinc, 42
Tantalum, 20
Tarnish, 111, 128, 160, 163
Tartar salts, 25
Tellurium, 20
Temperature, 29, 91, 111, 134, 183, 226
Terbium, 20
Terminal, 58
Terminal voltage, 31, 72
Thallium, 20
Tharium, 20
Thermometer, 134, 247
Thermometers, comparison of, 247
Three-wire system, 80
Thulium, 20
Thumb piece, 121
Tie bolt, 89
Tie rod, 88
Time, 120
Tin, 12, 18, 21, 167, 181, 187
Tin chloride, 25, 166, 187
Tin plates, 121
Tin plating, 187
Tin plating solutions, 187
Tin anode, 187
Tire rims, 110
Titanium, 20
Trade, 42
Transmission of power, 238
Trioxide, arsenic, 164
Tripoli, 218
Trough, 215
Trough, emery, 215
Troy weight, 253
Trucking, 41
Tube, brass, 95
Tube, copper, 95
Tubing, metal, 110
Tumbler, 97
Tumbler, horizontal, 140
Tumbler, oblique, 140
Tumbling, 110, 140, 143, 150
Tumbling barrel, 140, 148, 194
Tungsten, 20
Turpentine, 174
Two wire system, 79–80
Type, 13

U

Unbleached muslin, 217
Uni-direction current, 62
Unit, driving, 39, 69
Unit, electrical, 7
Unit, heating, 50
Unit length, 33
Unit of work, 37
Units, 21, 34, 35-36
Units, of quantity, 30
Uranium, 20
U. S. Bureau of Standards, 14, 169

V

Valency, 29
Valve, adjusting, 92
Valve, air, 146
Valve, regulating, 92, 94
Vanadium, 20
Vapors, 47, 112
Vapors, acid, 50
Vapors, poisonous, 242
Varnish, 12

Varnish, electrotypers', 159
Vat, dipping, 48
Vat, rinsing, 112
Vat, stoneware, 83
Vats, 83
Velocity, belt, 241
Ventilating devices, 203
Ventilating ducts, 63
Ventilating equipment, 133
Ventilating fan, 47, 205
Ventilating hood, 42, 112, 176, 229
Ventilating system, 47, 50
Ventilation, natural, 47
Ventilator, 226
Ventilator, roof, 42, 204
Vitriol, blue, 25
Vitriol, oil of, 25
Vitriol, white, 25
Voltage, 44, 58, 65, 72, 94, 102, 171
Voltage, constant, 65
Voltage regulation, 59, 169, 173, 180, 191
Voltage, terminal, 31, 72
Voltmeter, 31, 36, 61, 74, 79, 236
Voltmeter pointer, 61
Volts, 30, 37, 71
Volume, 255

W

Walking surface, 45
Wall, 46
Wall, acid proof, 45
Wall support, 48
Warm solutions, 91
War work, 14
Washers, 42
Waste, of metal, 76
Waste, of power, 70
Water, 17, 21, 23, 28, 42
Water bath, 117
Water pipe, 30, 46
Water stains, 45
Water supply, 42, 113
Watt, 37, 38, 71
Watt-hour, 38
Weight, absolute, 21
Weight, atomic, 21, 24–29
Weight, combining, 22
Weight, equivalent, 29
Weight, metric, 253
Weight, relative, 21
Weight, Troy, 253
Weights, 253-255
Welded tank, 85
Welding, 84
Wheel, buffing, 215
Wheel, buff leather, 218
Wheel, bullneck polishing, 209
Wheel, canvas, 207, 213
Wheel, compress, 209
Wheel, cotton wick buff, 217-218
Wheel, disc, 206
Wheel, emery, 140
Wheel, grinding, 201, 204
Wheel, leather, 216
Wheel, paper, 207
Wheel, polishing, 204, 215
Wheel rims, automobile, 109
Wheel, sheepskin polishing, 207
Wheel, wooden polishing, 205-206
White lead, 25
White vitriol, 25
Winding, armature, 232
Winding, bobbin, 73
Winding, field, 58, 236
Winding, shunt, 58
Windings, 44, 58, 65, 236
Window, 47, 49, 204
Wire, 57, 59, 61, 62, 108
Wire, armature, 61
Wire basket, 132
Wire hooks, 161
Wire mesh, 108
Wire, round, 32
Wire, slinging, 126, 173
Wood, 47
Wooden plating tank, 88-89
Wooden polishing wheel, 206-207
Wooden tank, 85
Woolen cloth buffs, 216-217

Work, commercial, 40
Working plane, 49
Workman, 41, 49, 69, 72, 203, 207
Woven wire brush, 68

X

Xenon, 20

Y

Ytterbium, 20
Yttrium, 20

Z

Zinc, 12, 17, 20, 160, 167, 181, 247
Zinc anodes, 191
Zinc cyanide, 24, 164, 190
Zinc deposition, 163, 191
Zinc plating, 13, 193
Zinc plating solutions, 189
Zinc plating, steel tank, 189
Zinc sulphate, 23, 179, 189, 191
Zinc tank, 42
Zirconium, 20

1920

REVISED

CATALOGUE

of LATEST *and* BEST

Practical and Mechanical Books

Including Automobile and Aviation Books

PRACTICAL BOOKS FOR PRACTICAL MEN

Any of these books will be sent prepaid to any part of the world, on receipt of price. Remit by Draft, Postal Order, Express Order or Registered Letter.

Published and For Sale by
The Norman W. Henley Publishing Co.
2 West 45th Street New York, U. S. A.

INDEX TO SUBJECTS

Accidents 27
Air Brake 25, 26
Arithmetic 15, 29, 38
Automobiles 3, 4, 5, 6, 7
Automobile Charts 7
Aviation 8
Batteries 18
Bevel Gears 22
Brazing and Soldering. 9
Cams 22
Charts 7, 8, 9
Chemistry 21
Civil Engineering 29
Coke 10
Compressed Air 10
Concrete 10, 11, 12, 13
Cosmetics 34
Dictionaries 14
Dies—Metal Work ..13, 14
Drawing—Sketching Paper 14, 15
Electric Bells 16
Electricity..15, 16, 17, 18, 19

Encyclopedia 29
Factory Management, etc. 19
Ford Automobile 6
Fuel 20
Flying Machines 8
Gas Engines and Gas, 20, 21, 22
Gearing and Cams 22
Hydraulics 22
Ice and Refrigeration.. 22
Inventions—Patents ... 23
Knots 23
Lathe Work 23, 24
Link Motion 25
Liquid Air 24
Locomotive Engineering, 24, 25, 26, 27
Machine Shop Practice, 27, 29, 30, 31
Manual Training 32
Marine Engineering ... 32
Mechanical Magazine .. 28
Mechanical Movements. 30
Metal Turning 23
Metal Work Dies 13, 14
Mining 33
Motor Cycles 6, 7
Patents and Inventions. 23
Pattern Making 33
Perfumery 34
Plumbing 34
Receipt Book 35, 40
Refrigeration and Ice.. 22
Repairing Automobiles.. 6
Rubber 36
Saws 36
Screw Cutting 36
Sheet Metal Work ...13, 14
Smoke Prevention 20
Soldering 9
Starting Systems 5
Steam Engineering.36, 37, 38
Steam Heating and Ventilation 38
Steel 38, 39
Storage Batteries 18
Switch Boards 17, 19
Tractor 22, 39
Turbines 39
Ventilation 38
Waterproofing 13
Welding 5
Wiring 17, 18
Wireless Telephones .. 19

☞Any of these books will be sent prepaid to any part of the world, on receipt of price.

REMIT by Draft, Postal Money Order, Express Money Order, or by Registered Mail.

GOOD, USEFUL BOOKS

AUTOMOBILES—MOTORCYCLES

The Modern Gasoline Automobile, Its Design, Construction, Operation.

By Victor W. Pagé, M.S.A.E. This is the most complete, practical, and up-to-date treatise on gasoline automobiles and their component parts ever published. In the new revised and enlarged 1920 edition, all phases of automobile construction, operation and maintenance are fully and completely described and in language anyone can understand. Every part of all types of automobiles, from light cyclecars to heavy motor trucks and tractors, are described in a thorough manner; not only the automobile, but every item of its equipment, accessories, tools needed, supplies and spare parts necessary for its upkeep, are fully discussed. It is clearly and concisely written by an expert familiar with every branch of the automobile industry and the originator of the practical system of self-education on technical subjects; it is a liberal education in the automobile art, useful to all who motor for either business or pleasure. Anyone reading the incomparable treatise is in touch with all improvements that have been made in motor car construction. All latest developments, such as high speed aluminum motors and multiple valve and sleeve valve engines, are considered in detail. The latest ignition, carburetor and lubrication practice is outlined. New forms of change speed gears, and final power transmission systems, and all latest chassis improvements, are shown and described. This book is used as a text in all leading automobile schools, and is conceded to be the standard treatise. The chapter on Starting and Lighting Systems has been greatly enlarged, and many automobile engineering features that have long puzzled laymen are explained so clearly that the underlying principles can be understood by anyone. This book was first published six years ago, and so much new matter has been added to the book that it is nearly twice its original size. The only treatise covering various forms of war automobiles and recent developments in motor truck design, as well as pleasure cars. This book is not too technical for the layman nor too elementary for the more expert. It is an incomparable work of reference for home or school. 6 x 9. Cloth, 1,000 pages, nearly 1,000 illustrations, 12 folding plates.

Price, $4.00

Questions and Answers Relating to Modern Automobile Construction, Driving and Repair.

By Victor W. Pagé. A self-educator on automobiling without an equal. This practical treatise consists of a series of thirty-seven lessons, covering with over 2,000 questions and their answers—the automobile, its construction, operation and repair. The subject matter is absolutely correct and explained in simple language. If you can't answer all of the following questions, you need this work. The answers to these and 2,000 more are to be found in its pages.

Give the name of all important parts of an automobile and describe their functions. Describe action of latest types of kerosene carburetors. What is the difference between a "double" ignition system and a "dual" ignition system? Name parts of an induction coil. How are valves timed? What is an electric motor starter and how does it work? What are advantages of worm drive-gearing? Name all important types of ball and roller bearings. What is a "three-quarter" floating axle? What is a two-speed axle? What is the Vulcan electric gear shift? Name the causes of lost power in automobiles. Describe all noises due to deranged mechanism and give causes. How can you adjust a carburetor by the color of the exhaust gases? What causes "popping" in the carburetor? What tools and supplies are needed to equip a car? How do you drive various makes of cars? What is a differential lock and where is it used? Name different systems of wire wheel construction. What is a "positive" drive differential? etc., etc. Answers every question asked relating to the modern automobile. A popular work at a popular price. 5¼ x 7½. Cloth, 650 pages, 392 illustrations, 3 folding plates. 1920 Edition just published.

Price, $2.50

How to Run an Automobile.

By Victor W. Pagé. This treatise gives concise instructions for starting and running all makes of gasoline automobiles, how to care for them, and gives distinctive features of control. Describes every step for shifting gears, controlling engine, etc. Among the chapters contained are: I. Automobile Parts and Their Functions. II. General Starting and Driving Instructions. III. Typical 1919 Control Systems—Care of Automobiles. Thoroughly illustrated. 178 pages, 72 illustrations.

Price, $1.50

The Automobilist's Pocket Companion and Expense Record.

By Victor W. Pagé. This book is not only valuable as a convenient cost record, but contains much information of value to motorists. Includes a condensed digest of auto laws of all States, a lubrication schedule, hints for care of storage battery and care of tires, location of road troubles, anti-freezing solutions, horsepower table, driving hints and many useful tables and recipes of interest to all motorists. Not a technical book in any sense of the word, just a collection of practical facts in simple language for the everyday motorist. Convenient pocket size.

Price, $1.25

Gasoline and Kerosene Carburetors, Construction, Installation and Adjustment.

By Capt. V. W. Pagé. All leading types of carburetors are described in detail, special attention being given to the forms devised to use the cheaper fuels such as kerosene. Carburetion troubles, fuel system troubles, carburetor repairs and installation, electric primers and economizers, hot spot manifolds and all modern carburetor developments are considered in a thorough manner. Methods of adjusting all types of carburetors are fully discussed as well as suggestions for securing maximum fuel economy and obtaining highest engine power. 250 pages, 89 illustrations. **Price, $2.00**

Starting, Lighting and Ignition Systems.

By Victor W. Pagé. A practical treatise on latest automobile starting, lighting and ignition system practice. This practical volume has been written with special reference to the requirements of the reader desiring easily understood explanatory matter relating to all types of automobile electrical systems. It can be understood by anyone, even without electrical knowledge, because elementary electrical principles are considered before any attempt is made to discuss features of the various systems. These basic principles are clearly stated and illustrated with simple diagrams. All the leading systems of starting, lighting and ignition have been described and illustrated with the cooperation of the experts employed by the manufacturers. Over 200 wiring diagrams are shown in both technical and nontechnical forms. Complete data is given for locating troubles in all systems, the various steps being considered in a logical way for those without expert electrical knowledge. All ignition systems receive full consideration, starting with the simplest battery and coil forms found on early cars to the modern short-contact timer and magneto methods used with the latest eight and twelve-cylinder motors. Full directions are given for making all repairs and complete instructions for locating troubles with meters. This book is unusually complete, as it also includes descriptions of various accessories operated by electric current, such as electrical gear shifts, brake actuation, signaling devices, vulcanizers, etc. Over 700 pages. 425 specially made engravings. 1920 Edition, Revised and Enlarged. **Price, $3.00**

Automobile Welding with the Oxy-Acetylene Flame.

By M. Keith Dunham. Explains in a simple manner apparatus to be used, its care, and how to construct necessary shop equipment. Proceeds then to the actual welding of all automobile parts, in a manner understandable by everyone. *Gives principles never to be forgotten.* This book is of utmost value, since the perplexing problems arising when metal is heated to a melting point are fully explained and the proper methods to overcome them shown. 167 pages, fully illustrated. **Price, $1.50**

Automobile Repairing Made Easy.

By Victor W. Pagé. A thoroughly practical book containing complete directions for making repairs to all parts of the motor car mechanism. Written in a thorough but non-technical manner. Gives plans for workshop construction, suggestions for equipment, power needed, machinery and tools necessary to carry on business successfully. Tells how to overhaul and repair all parts of all automobiles. The information given is founded on practical experience, everything is explained so simply that motorists and students can acquire a full working knowledge of automobile repairing. Other works dealing with repairing cover only certain parts of the car—this work starts with the engine, then considers carburetion, ignition, cooling and lubrication systems. The clutch, change speed gearing and transmission system are considered in detail. Contains instructions for repairing all types of axles, steering gears and other chassis parts. Many tables, short cuts in figuring and rules of practice are given for the mechanic. Explains fully valve and magneto timing, "tuning" engines, systematic location of trouble, repair of ball and roller bearing, shop kinks, first aid to injured and a multitude of subjects of interest to all in the garage and repair business. All illustrations are especially made for this book, and are actual photographs or reproductions of engineering drawings. This book also contains Special Instructions on Electric Starting, Lighting and Ignition Systems, Tire Repairing and Rebuilding, Autogenous Welding, Brazing and Soldering, Heat Treatment of Steel, Latest Timing Practice, Eight and Twelve-Cylinder Motors, etc., etc. You will never "Get Stuck" on a Job if you own this book. 1,000 specially made engravings on 500 plates. 1,056 pages (5½ x 8). 1920 Edition. **Price, $4.00**

The Model T Ford Car, Its Construction, Operation and Repair, Including the Fordson Farm Tractor, F. A. Lighting and Starting System, Ford Motor Truck.

By Victor W. Pagé. This is the most complete and practical instruction book ever published on the Ford car and Fordson tractor. A high grade, cloth bound book, printed on the best paper, illustrated by specially made drawings and photographs. All parts of the Ford Model T car and Fordson tractor are described and illustrated in a comprehensive manner. The construction is fully treated and operating principle made clear to everyone. Complete instructions for driving and repairing are given. To the 1920 Revised Edition matter has been added on the Ford Truck and Tractor Conversion Sets and Genuine Fordson Tractor. All parts are described. All repair processes illustrated and fully explained. Written so all can understand—no theory, no guesswork. New Edition. 153 illustrations, 410 pages, 2 large folding plates. **Price, $2.00**

Motorcycles, Side Cars and Cyclecars, Their Construction, Management and Repair.

By Victor W. Pagé. Describes fully all leading types of machines, their design, construction, maintenance, operation and repair. 550 pages. 350 specially made illustrations, 5 folding plates. New Edition. **Price, $2.50**

Automobile Charts

By VICTOR W. PAGÉ, M.S.A.E.

THE POPULAR AUTOMOBILE SERIES
UNIFORM SIZE—24″ x 38″—PRICE 35 CENTS EACH

Location of Gasoline Engine Troubles Made Easy.

This chart shows clearly all parts of a typical four-cylinder gasoline engine of the four-cycle type. It simplifies location of all engine troubles. No details omitted. **Price, 35 cents**

Location of Carburetion Troubles Made Easy.

It shows clearly how to find carburetion troubles and names all defects liable to exist in the various parts. Instructions are given for carburetor adjustment. **Price, 35 cents**

Location of Ignition System Troubles Made Easy.

In this chart all parts of a typical double ignition system using battery and magneto current are shown, and suggestions are given for readily finding ignition troubles and eliminating them when found. **Price, 35 cents**

Location of Cooling and Lubricating Troubles.

This is a combination chart showing all components of the approved form of water cooling group as well as a modern engine lubrication system. It shows all points where defects exist that may result in engine overheating, both in cooling and oiling systems. **Price, 35 cents**

Lubrication of the Motor Car Chassis.

This chart presents the plan view of a typical six-cylinder chassis of standard design and outlines all important bearing points requiring lubrication, and is a valuable guide to the correct lubrication of any modern car. A practical chart for all interested in motor car maintenance. **Price, 35 cents**

While each chart is complete in itself, the set covers all maintenance instructions for the entire automobile. Sold singly. Securely wrapped.

Location of Starting and Lighting System Faults.

The most complete chart yet devised, showing all parts of the modern automobile starting, lighting and ignition systems, giving instructions for systematic location of all faults in wiring, lamps, motor or generator, switches and all other units. Invaluable to motorists, chauffeurs and repairmen. Size 24 x 38 inches. **Price, 35 cents**

Location of Ford Engine Troubles Made Easy.

Chart showing clear sectional views depicting all portions of the Ford power plant and auxiliary groups. It outlines clearly all parts of the engine, fuel supply systems, ignition group and cooling system, that are apt to give trouble, detailing all derangements that are liable to make an engine lose power, start hard, or work irregularly. This chart simplifies location of all engine faults. Size 25 x 38 inches. **Price, 35 cents**

Location of Motorcycle Troubles Made Easy.

This chart simplifies location of all power-plant troubles and will prove of value to all who have to do with the operation, repair or sale of motorcycles. No details omitted. Size 30 x 20 inches. **Price, 35 cents**

AVIATION

A B C of Aviation.

By Capt. V. W. Pagé. This book describes the basic principles of aviation, tells how a balloon or dirigible is made and why it floats in the air. Describes how an airplane flies. It shows in detail the different parts of an airplane, what they are and what they do. Describes all types of airplanes and how they differ in construction; as well as detailing the advantages and disadvantages of different types of aircraft. It includes a complete dictionary of aviation terms and clear drawings of leading airplanes. The reader will find simple instructions for unpacking, setting up and rigging airplanes. A full description of airplane control principles is given and methods of flying are discussed at length.

This Book answers every question one can ask about modern aircraft, their construction and operation. A self educator on aviation without an equal. 275 pages, 130 specially made illustrations with 7 plates. **Price, $2.50**

Aviation Engines—Design; Construction; Repair.

By Lieut. Victor W. Pagé, Aviation Section, S.C.U.S.R. This treatise, written by a recognized authority on all of the practical aspects of internal combustion engine construction, maintenance and repair, fills the need as no other book does. The matter is logically arranged; all descriptive matter is simply expressed and copiously illustrated, so that anyone can understand airplane engine operation and repair even if without previous mechanical training. This work is invaluable for anyone desiring to become an aviator or aviation mechanician.

The latest rotary types, such as the Gnome Monosoupape, and LeRhone, are fully explained, as well as the recently developed Vee and radial types. The subjects of carburetion, ignition, cooling and lubrication also are covered in a thorough manner. The chapters on repair and maintenance are distinctive and found in no other book on this subject. Not a technical book, but a practical, easily understood work of reference for all interested in aeronautical science. 576 pages, 253 illustrations. **Price, Net, $3.00**

Glossary of Aviation Terms — English-French; French-English.

A complete glossary of practically all terms used in aviation, having lists in both French and English with equivalents in either language compiled by Lieuts. Victor W. Pagé, A.S., S.C.U.S.R., and Paul Montariol, of the French Flying Corps. **Price, Net, $1.00**

Aviation Chart — Location of Airplane Power Plant Troubles Made Easy.

By Lieut. Victor W. Pagé, A.S., S.C.U.S.R. A large chart outlining all parts of a typical airplane power plant, showing the points where trouble is apt to occur and suggesting remedies for the common defects. Intended especially for aviators and aviation mechanics on school and field duty. **Price, 35 cents**

BRAZING AND SOLDERING

Brazing and Soldering.

By James F. Hobart. The only book that shows you just how to handle any job of brazing or soldering that comes along; it tells you what mixture to use, how to make a furnace if you need one. Full of valuable kinks. The fifth edition of this book has just been published, and to it much new matter and a large number of tested formulas for all kinds of solders and fluxes have been added. **Price, 35c.**

CHARTS

Aviation Chart — Location of Airplane Power Plant Troubles Made Easy.

By Lieut. Victor W. Pagé, A.S., S.C.U.S.R. A large chart outlining all parts of a typical airplane power plant, showing the points where trouble is apt to occur and suggesting remedies for the common defects. Intended especially for aviators and aviation mechanics on school and field duty. **Price, 35 cents**

Modern Submarine Chart—With 200 Parts Numbered and Named.

A cross-section view, showing clearly and distinctly all the interior of a submarine of the latest type. No details omitted—everything is accurate and to scale. This chart is really an encyclopedia of a submarine. **Price, 25 cents**

Box Car Chart.

A chart showing the anatomy of a box car, having every part of the car numbered and its proper name given in a reference list. **Price, 25 cents**

Gondola Car Chart.

A chart showing the anatomy of a gondola car, having every part of the car numbered and its proper reference name given in a reference list. **Price, 25 cents**

Passenger Car Chart.

A chart showing the anatomy of a passenger car, having every part of the car numbered and its proper name given in a reference list. **Price, 25 cents**

Steel Hopper Bottom Coal Car.

A chart showing the anatomy of a steel hopper bottom coal car, having every part of the car numbered and its proper name given in a reference list. **Price, 25 cents**

Tractive Power Chart.

A chart whereby you can find the tractive power or drawbar pull of any locomotive without making a figure. Shows what cylinders are equal, how driving wheels and steam pressure affect the power. What sized engine you need to exert a given drawbar pull or anything you desire in this line. **Price, 50 cents**

Horse-power Chart.

Shows the horse-power of any stationary engine without calculation. No matter what the cylinder diameter of stroke, the steam pressure or cut-off, the revolutions, or whether condensing or non-condensing, it's all there. Easy to use, accurate and saves time and calculations. Especially useful to engineers and designers. **Price, 50 cents**

Boiler Room Chart.

By George L. Fowler. A chart—size 14 x 28 inches—showing in isometric perspective the mechanisms belonging in a modern boiler room. This chart is really a dictionary of the boiler room—the names of more than 200 parts being given.

Price, 25 cents

COKE

Coke—Modern Coking Practice, Including Analysis of Materials and Products.

By J. E. Christopher and T. H. Byrom. This, the standard work on the subject, has just been revised and is now issued in two volumes. It is a practical work for those engaged in Coke manufacture and the recovery of By-products. Fully illustrated with folding plates. It has been the aim of the authors, in preparing this book, to produce one which shall be of use and benefit to those who are associated with, or interested in, the modern developments of the industry. Among the chapters contained in Volume I are: Introduction; Classification of Fuels; Impurities of Coals; Coal Washing; Sampling and Valuation of Coals, etc.; Chlorific Power of Fuels; History of Coke Manufacture; Developments in Coke Oven Design; Recent Types of Coke Ovens; Mechanical Appliances at Coke Ovens; Chemical and Physical Examination of Coke. Volume II covers By-products. Each volume is fully illustrated, with folding plates.

Price, $3.00 per volume

COMPRESSED AIR

Compressed Air in all Its Applications.

By Gardner D. Hiscox. This is the most complete book on the subject of air that has ever been issued, and its thirty-five chapters include about every phase of the subject one can think of. It may be called an encyclopedia of compressed air. It is written by an expert, who, in its 665 pages, has dealt with the subject in a comprehensive manner, no phase of it being omitted. Over 500 illustrations. Fifth Edition, revised and enlarged. Cloth bound, **$6.00.** Half Morocco, revised and enlarged. Cloth bound. **Price, $6.00**

CONCRETE

Concrete Wall Forms.

By A. A. Houghton. A new automatic wall clamp, is illustrated with working drawings. Other types of wall forms, clamps, separators, etc., are also illustrated and explained.

Price, 75 cents

Concrete Floors and Sidewalks.

By A. A. Houghton. The molds for molding squares, hexagonal and many other styles of mosaic floor and sidewalk blocks are fully illustrated and explained. **Price, 75 cents**

Practical Concrete Silo Construction.

By A. A. Houghton. Complete working drawings and specifications are given for several styles of concrete silos, with illustrations of molds for monolithic and block silos. The tables, data, and information presented in this book are of the utmost value in planning and constructing all forms of concrete silos. **Price, 75 cents**

Molding Concrete Bath Tubs, Aquariums and Natatoriums.

By A. A. Houghton. Simple molds and instruction are given for molding different styles of concrete bath tubs, swimming pools, etc. **Price, 75 cents**

Molding Concrete Chimneys, Slate and Roof Tiles.

By A. A. Houghton. The manufacture of all types of concrete slate and roof tile is fully treated. Valuable data on all forms of reinforced concrete roofs are contained within its pages. The construction of concrete chimneys by block and monolithic systems is fully illustrated and described. A number of ornamental designs of chimney construction with molds are shown in this valuable treatise. **75 cents**

Molding and Curing Ornamental Concrete.

By A. A. Houghton. The proper proportions of cement and aggregates for various finishes, also the methods of thoroughly mixing and placing in the molds, are fully treated. An exhaustive treatise on this subject that every concrete worker will find of daily use and value. **Price, 75 cents**

Concrete Monuments, Mausoleums and Burial Vaults.

By A. A. Houghton. The molding of concrete monuments to imitate the most expensive cut stone is explained in this treatise, with working drawings of easily built molds. Cutting inscriptions and designs is also fully treated. **75 cents**

Concrete Bridges, Culverts and Sewers.

By A. A. Houghton. A number of ornamental concrete bridges with illustrations of molds are given. A collapsible center of core for bridges, culverts and sewers is fully illustrated with detailed instructions for building. **75 cents**

Constructing Concrete Porches.

By A. A. Houghton. A number of designs with working drawings of molds are fully explained so any one can easily construct different styles of ornamental concrete porches without the purchase of expensive molds. **Price, 75 cents**

Molding Concrete Flower Pots, Boxes, Jardinieres, Etc.

By A. A. Houghton. The molds for producing many original designs of flower pots, urns, flower boxes, jardinieres, etc., are fully illustrated and explained, so the worker can easily construct and operate same. **Price, 75 cents**

Molding Concrete Fountains and Lawn Ornaments.

By A. A. Houghton. The molding of a number of designs of lawn seats, curbing, hitching posts, pergolas, sun dials and other forms of ornamental concrete, for the ornamentation of lawns and gardens, is fully illustrated and described. **75c.**

Concrete on the Farm and in the Shop.

By H. Colvin Campbell. This is a new book from cover to cover, illustrating and describing in plain, simple language many of the numerous appliances of concrete within the range of the home worker. Among the subjects treated are: Principles of reinforcing; methods of protecting concrete so as to insure proper hardening; home-made mixers; mixing by hand and machine; form construction, described and illustrated by drawings and photographs; construction of concrete walls and fences; concrete fence posts; concrete gate posts; corner posts; clothes line posts; grape arbor posts; tanks; troughs; cisterns: hog wallows; feeding floors and barnyard pavements; foundations; well curbs and platforms; indoor floors; sidewalks; steps; concrete hotbeds and cold frames; concrete slab roofs; walls for buildings; repairing leaks in tanks and cisterns; and all topics associated with these subjects as bearing upon securing the best results from concrete are dwelt upon at sufficient length in plain every-day English so that the inexperienced person desiring to undertake a piece of concrete construction can, by following the directions set forth in this book, secure 100 per cent success every time. A number of convenient and practical tables for estimating quantities, and some practical examples, are also given. 150 pages, 51 illustrations. **Price, $1.00**

Concrete From Sand Molds.

By A. A. Houghton. A practical work treating on a process which has heretofore been held as a trade secret by the few who possessed it, and which will successfully mold every and any class of ornamental concrete work. The process of molding concrete with sand molds is of the utmost practical value, possessing the manifold advantages of a low cost of molds, the ease and rapidity of operation, perfect details to all ornamental designs, density and increased strength of the concrete, perfect curing of the work without attention and the easy removal of the molds regardless of any undercutting the design may have. 192 pages. Fully illustrated. Cloth. **Price, $2.00**

Ornamental Concrete Without Molds.

By A. A. Houghton. The process for making ornamental concrete without molds has long been held as a secret, and now, for the first time, this process is given to the public. The book reveals the secret and is the only book published which explains a simple, practical method whereby the concrete worker is enabled, by employing wood and metal templates of different designs, to mold or model in concrete any cornice, archivolt, column, pedestal, base cap, urn or pier in a monolithic form—right upon the job. These may be molded in units or blocks, and then built up to suit the specifications demanded. This work is fully illustrated, with detailed engravings. Cloth. **Price, $2.00**

Popular Handbook for Cement and Concrete Users.

By Myron H. Lewis. Everything of value to the concrete user is contained, including kinds of cement employed in construction, concrete architecture, inspection and testing, waterproofing, coloring and painting, rules tables, working and cost data. The book comprises thirty-three chapters. A valuable addition to the library of every cement and concrete user. Cloth, 430 pages, 126 illustrations. **Price, $3.00**

Waterproofing Concrete.

By Myron H. Lewis. Modern methods of waterproofing concrete and other structures. A condensed statement of the principles, rules and precautions to be observed in waterproofing and damp-proofing structures and structural materials. Paper binding. Illustrated. Second Edition. **75 cents**

DIES—METAL WORK

Dies; Their Construction and Use for the Modern Working of Sheet Metals.

By J. V. Woodworth. A new book by a practical man, for those who wish to know the latest practice in the working of sheet metals. It shows how dies are designed, made and used, and those who are engaged in this line of work can secure many valuable suggestions. Sixth revised edition. 525 illustrations, 394 pages. Cloth. **Price, $3.50**

Punches, Dies and Tools for Manufacturing in Presses.

By J. V. Woodworth. An encyclopedia of die-making, punch-making, die-sinking, sheet-metal working, and making of special tools, subpresses, devices and mechanical combinations for punching, cutting, bending, forming, piercing, drawing, compressing, and assembling sheet-metal parts and also articles of other materials in machine tools. This is a distinct work from the author's book entitled "Dies; Their Construction and Use." 500 pages, 700 engravings. Second edition. Cloth. **Price, $4.50**

Drop Forging, Die-Sinking and Machine-Forming of Steel.

By J. V. Woodworth. The processes of die-sinking and force-making, which are thoroughly described and illustrated in this admirable work, are rarely to be found explained in such a clear and concise manner as is here set forth. The process of die-sinking relates to the engraving or sinking of the female or lower dies, such as are used for drop forgings, hot and cold machine forging, swedging and the press working of metals. The process of force-making relates to the engraving or raising of the male or upper dies used in producing the lower dies for the press-forming and machine-forging of duplicate parts of metal. The book contains eleven chapters, and the information contained in these chapters is just what will prove most valuable to the forged-metal worker. 304 detailed illustrations. 341 pages, cloth. **Price, $3.00**

DICTIONARIES

Aviation Terms—English-French; French-English.

A complete glossary of practically all terms used in aviation, having lists in both French and English with equivalents in either language. A very valuable book compiled by Lieuts. Victor W. Pagé and Paul Montariol. **Price, $1.00**

Standard Electrical Dictionary.

By Prof. T. O'Conor Sloane. Just issued an entirely new edition brought up to date and greatly enlarged—as a reference book this work is beyond comparison as it contains over 700 pages, nearly 500 illustrations, and definitions of about 6,000 distinct words, terms and phrases. The definitions are terse and concise and includes every term used in electrical science.

In its arrangement and typography the book is very convenient. The word or term defined is printed in black faced type which readily catches the eye, while the body of the page is in smaller but distinct type. The definitions are well worded, and so as to be understood by the non-technical reader. The general plan is to give an exact, concise definition, and then amplify and explain in a more popular way. Synonyms are also given, and references to other words and phrases are made. This work is absolutely indispensable to all in any way interested in electrical science, from the higher electrical expert to the everyday electrical workman. In fact, it should be in the possession of all who desire to keep abreast with the progress of this branch of science. 1920 enlarged edition. Nearly 800 pages and nearly 400 illustrations. **Price, $5.00**

DRAWING—SKETCHING PAPER

Linear Perspective Self-Taught.

By Herman T. C. Kraus. This work gives the theory and practice of linear perspective, as used in architectural, engineering and mechanical drawings. The arrangement of the book is good; the plate is on the left-hand, while the descriptive text follows on the opposite page, so as to be readily referred to. A self-explanatory linear perspective chart is included in the second revised edition. Cloth. **Price, $3.00**

Self-Taught Mechanical Drawing and Elementary Machine Design.

By F. L. Sylvester, M.E., Draftsman, with additions by Erik Oberg, associate editor of "Machinery." A practical elementary treatise on Mechanical Drawing and Machine Design, comprising the first principles of geometric and mechanical drawing, workshop mathematics, mechanics, strength of materials and the calculation and design of machine details, compiled for the use of practical mechanics and young draftsmen. 330 pages, 215 engravings, cloth. **Price, $2.50**

A New Sketching Paper.

A new specially ruled paper to enable you to make sketches or drawings in isometric perspective without any figuring or fussing. It is being used for shop details as well as for assembly drawings, as it makes one sketch do the work of three, and no workman can help seeing just what is wanted. Pads of 40 sheets, 6 x 9 inches, **Price, 25c.;** 9 x 12 inches, **Price, 50c.;** 12 x 18 inches, **Price, $1.00.**

Practical Perspective.

By Richards and Colvin. Shows just how to make all kinds of mechanical drawings in the only practical perspective isometric. Makes everything plain so that any mechanic can understand a sketch or drawing in this way. Saves time in the drawing room and mistakes in the shops. Contains practical examples of various classes of work. Third edition. Limp cloth. **Price, 75 cents**

ELECTRICITY

Arithmetic of Electricity.

By Prof. T. O'Conor Sloane. A practical treatise on electrical calculations of all kinds reduced to a series of rules, all of the simplest forms, and involving only ordinary arithmetic; each rule illustrated by one or more practical problems with detailed solution of each one. This book is classed among the most useful works published on the science of electricity, covering as it does the mathematics of electricity in a manner that will attract the attention of those who are not familiar with algebraical formulas. 200 pages. 1920 Revised and Enlarged edition. **Price, $1.50**

Dynamo Building for Amateurs, or How to Construct a Fifty Watt Dynamo.

By Arthur J. Weed. A practical treatise showing in detail the construction of a small dynamo or motor, the entire machine work of which can be done on a small foot lathe. Dimensioned working drawings are given for each piece of machine work, and each operation is clearly described. This machine, when used as a dynamo, has an output of fifty watts; when used as a motor it will drive a small drill press or lathe. It can be used to drive a sewing machine on any and all ordinary work. The book is illustrated with more than sixty original engravings showing the actual construction of the different parts. **Price, Cloth, $1.00**

Electric Bells.

By M. B. Sleeper. A complete treatise for the practical worker in installing, operating and testing bell circuits, burglar alarms, thermostats and other apparatus used with electric bells. Both the electrician and the experimenter will find in this book new material which is essential in their work. Tools, bells, batteries, unusual circuits, burglar alarms, annunciators, systems, thermostats, circuit breakers, time alarms, and other apparatus used in bell circuits are described from the standpoints of their application, construction, and repair. The detailed instructions for building the apparatus will appeal to the experimenter particularly. The practical worker will find the chapters on Wiring Calculation of Wire Sizes and Magnet Windings, Upkeep of Systems and the Location of Faults of the greatest value in their work. 124 pages. Fully illustrated. **Price, 75 cents.**

Commutator Construction

By Wm. Baxter, Jr. The business end of dynamo or motor of the direct current type is the commutator. This book goes into the designing, building and maintenance of commutators, shows how to locate troubles and how to remedy them; everyone who fusses with dynamos needs this. Fourth edition. **Price, 35 cents.**

Dynamos and Electric Motors and All About Them.

By Edward Trevert. This volume gives practical directions for building a two H. P. Dynamo of the Edison type capable of lighting about fifty mazda lamps of the 20 watt size. In addition, it gives directions for building two small electric motors suitable for running sewing machines. The concluding chapter describes the construction of a simple bichromate battery adapted for running electric motors. 96 pages. Fully illustrated with detail drawings. Cloth. **Price, $1.00.**

Construction of a Transatlantic Wireless Receiving Set.

By L. G. Pacent and T. S. Curtis. A work for the Radio student who desires to construct and operate apparatus that will permit of the reception of messages from the large stations in Europe with an aerial of amateur proportions. 36 pages. 23 illustrations, cloth. **Price, 35 cents.**

Electric Toy Making, Dynamo Building and Electric Motor Construction.

This work treats of the making at home of electrical toys, electrical apparatus, motors, dynamos and instruments in general and is designed to bring within the reach of young and old the manufacture of genuine and useful electrical appliances. 210 pages, cloth. Fully illustrated. Twentieth edition, enlarged. **Price, $1.50**

Experimental High Frequency Apparatus, How to Make and Use It.

By Thomas Stanley Curtis. 69 pages, illustrated. **Price, 50 cents.**

Electrician's Handy Book.

By Prof. T. O'Conor Sloane. This work has just been revised and much enlarged. It is intended for the practical electrician who has to make things go. The entire field of electricity is covered within its pages. It is a work of the most modern practice, written in a clear, comprehensive manner, and covers the subject thoroughly, beginning at the A B C of the subject, and gradually takes you to the more advanced branches of the science. It teaches you just what you should know about electricity. A practical work for the practical man. Contains forty-eight chapters.

The publishers consider themselves fortunate in having secured the services of such a well and favorably known writer as Prof. Sloane, who has with the greatest care completed a master work in concise form on this all important subject. 600 engravings, 840 pages, handsomely bound in cloth. 1920 Edition. **Price, $4.00**

Electricity Simplified.

By Prof. T. O'Conor Sloane. The object of 'Electricity Simplified" is to make the subject as plain as possible and to show what the modern conception of electricity is; to show how two plates of different metals immersed in acid can send a message around the globe; to explain how a bundle of copper wire rotated by a steam engine can be the agent in lighting our streets, to tell what the volt, ohm and ampere are, and what high and low tension mean; and to answer the questions that perpetually arise in the mind in this age of electricity. 172 pages. Illustrated. Thirteenth edition. Cloth. **Price, $1.50**

Electric Wiring, Diagrams and Switchboards.

By Newton Harrison, with additions by Thomas Poppe. This is the only complete work issued showing and telling you what you should know about direct and alternating current wiring. The work is free from advanced technicalities and mathematics, arithmetic being used throughout. It is in every respect a handy, well-written, instructive, comprehensive volume on wiring for the wireman, foreman, contractor or electrician. Third revised edition. 303 pages, 130 illustrations. Cloth. **Price, $2.50**

House Wiring.

By Thomas W. Poppe. Describing and illustrating up-to-date methods of installing electric light wiring. Contains just the information needed for successful wiring of a building. Fully illustrated with diagrams and plans. It solves all wiring problems and contains nothing that conflicts with the rulings of the National Board of Fire Underwriters. Third edition revised and enlarged. 125 pages, fully illustrated, flexible cloth. **Price, 75 cents**

High Frequency Apparatus, Its Construction and Practical Application.

By Thomas Stanley Curtis. The most comprehensive and thorough work on this interesting subject ever produced. The book is essentially practical in its treatment and it constitutes an accurate record of the researches of its author over a period of several years, during which time dozens of coils were built and experimented with. New revised and enlarged 1920 edition. 275 pages. **Price, $3.00**

How to Become a Successful Electrician.

By Prof. T. O'Conor Sloane. An interesting book from cover to cover. Telling in simplest language the surest and easiest way to become a successful electrician. The studies to be followed, methods of work, field of operation and the requirements of the successful electrician are pointed out and fully explained. 202 pages. Illustrated. Eighteenth revised edition. Cloth. **Price, $1.50**

Standard Electrical Dictionary.

By Prof. T. O'Conor Sloane. Just issued an entirely new edition brought up to date and greatly enlarged—as a reference book this work is beyond comparison as it contains over 700 pages, nearly 500 illustrations, and definitions of about 6,000 distinct words, terms and phrases. The definitions are terse and concise and includes every term used in electrical science.

In its arrangement and typography the book is very convenient. The word or term defined is printed in black faced type which readily catches the eye, while the body of the page is in smaller but distinct type. The definitions are well worded, and so as to be understood by the non-technical reader. The general plan is to give an exact, concise definition, and then amplify and explain in a more popular way. Synonyms are also given, and references to other words and phrases are made. This work is absolutely indispensable to all in any way interested in electrical science, from the higher electrical expert to the everyday electrical workman. In fact, it should be in the possession of all who desire to keep abreast with the progress of this branch of science. 1920 enlarged edition. Nearly 800 pages. 400 illustrations.

Price, $5.00

Storage Batteries Simplified.

By Victor W. Pagé. M.S.A.E. This is the most thorough and authoritative treatise ever published on this subject. It is written in easily understandable, non-technical language so that any one may grasp the basic principles of storage battery action as well as their practical industrial applications. All electric and gasoline automobiles use storage batteries. Every automobile repairman, dealer or salesman should have a good knowledge of maintenance and repair of these important elements of the motor car mechanism. This book not only tells how to charge, care for and rebuild storage batteries but also outlines all the industrial uses. Learn how they run street cars, locomotives and factory trucks. Get an understanding of the important functions they perform in submarine boats, isolated lighting plants, railway switch and signal systems, marine applications, etc. This book tells how they are used in central station standby service, for starting automobile motors and in ignition systems. Every practical use of the modern storage battery is outlined in this treatise. 208 pages, fully illustrated.

Price, $2.00

Wiring a House.

By Herbert Pratt. Shows a house already built; tells just how to start about wiring it; where to begin; what wire to use; how to run it according to insurance rules; in fact, just the information you need. Directions apply equally to a shop. Fourth edition. **Price, 35 cents**

Switchboards.

By William Baxter, Jr. This book appeals to every engineer and electrician who wants to know the practical side of things. All sorts and conditions of dynamos, connections and circuits are shown by diagram and illustrate just how the switchboard should be connected. Includes direct and alternating current boards, also those for arc lighting, incandescent and power circuits. Special treatment on high voltage boards for power transmission. Second edition. 190 pages. Illustrated. **Price, $2.00**

Telephone Construction, Installation, Wiring, Operation and Maintenance.

By W. H. Radcliffe and H. C. Cushing. This book gives the principles of construction and operation of both the Bell and Independent instruments; approved methods of installing and wiring them; the means of protecting them from lightning and abnormal currents; their connection together for operation as series or bridging stations; and rules for their inspection and maintenance. Line wiring and the wiring and operation of special telephone systems are also treated. 224 pages, 132 illustrations. Second revised edition. **Price, $1.50**

Wireless Telegraphy and Telephony Simply Explained.

By Alfred P. Morgan. This is undoubtedly one of the most complete and comprehensive treatises on the subject ever published, and a close study of its pages will enable one to master all the details of the wireless transmission of messages. The author has filled a long-felt want and has succeeded in furnishing a lucid, comprehensible explanation in simple language of the theory and practise of wireless telegraphy and telephony. Third edition. 154 pages, 156 engravings. **Price, $1.50**

Radio Time Signal Receiver.

By Austin C. Lescarboura. This new book, "A Radio Time Signal Receiver," tells you how to build a simple outfit designed expressly for the beginner. You can build the outfits in your own workshop and install them for jewelers either on a one-payment or a rental basis. The apparatus is of such simple design that it may be made by the average amateur mechanic possessing a few ordinary tools. 42 pages. Paper. **Price, 35 cents**

Experimental Wireless Stations.

By P. E. Edelman. The theory, design, construction and operation is fully treated including Wireless Telephony, Vacuum Tube, and quenched spark systems. The new enlarged 1920 edition is just issued and is strictly up to date, correct and complete. This book tells how to make apparatus to not only hear all telephoned radio messages, but also how to make simple equipment that works for transmission over reasonably long distances. Then there is a host of new information included. The first and only book to give you all the recent important radio improvements, some of which have never before been published. 24 chapters. 167 illustrations. **Price, $2.50**

FUEL

Combustion of Coal and the Prevention of Smoke.

By Wm. M. Barr. This book has been prepared with special reference to the generation of heat by the combustion of the common fuels found in the United States, and deals particularly with the conditions necessary to the economic and smokeless combustion of bituminous coals in stationary and locomotive steam boilers. The presentation of this important subject is systematic and progressive. The arrangement of the book is in a series of practical questions, to which are appended accurate answers, which describe in language, free from technicalities, the several processes involved in the furnace combustion of American fuels; it clearly states the essential requisites for perfect combustion, and points out the best methods for furnace construction for obtaining the greatest quantity of heat from any given quality of coal. Nearly 350 pages, fully illustrated. Fifth edition. **Price, $1.50**

Smoke Prevention and Fuel Economy.

By Booth and Kershaw. As the title indicates, this book of 197 pages and 75 illustrations deals with the problem of complete combustion, which it treats from the chemical and mechanical standpoints, besides pointing out the economical and humanitarian aspects of the question. **Price, $3.00**

GAS ENGINES AND GAS

Gas, Gasoline and Oil Engines.

By Gardner D. Hiscox. Revised by Victor W. Pagé. Just issued new, revised and enlarged edition. Every user of a gas engine needs this book. Simple, instructive and right up-to-date. The only complete work on the subject. Tells all about internal combustion engineering, treating exhaustively on the design, construction and practical application of all forms of gas, gasoline, kerosene and crude petroleum-oil engines. Describes minutely all auxiliary systems, such as lubrication, carburetion and ignition. Considers the theory and management of all forms of explosive motors for stationary and marine work, automobiles, aeroplanes and motorcycles. Includes also Producer Gas and Its Production. Invaluable instructions for all students, gas-engine owners, gas-engineers, patent experts, designers, mechanics, draftsmen and all having to do with the modern power. Illustrated by over 400 engravings, many specially made from engineering drawings, all in correct proportion. Nearly 700 octavo pages and 500 engravings. **Price, net, $3.00**

Gasoline Engines: Their Operation, Use and Care.

By A. Hyatt Verrill. A comprehensive, simple and practical work, treating of gasoline engines for stationary, marine or vehicle use; their construction, design, management, care, operation, repair, installation and troubles. A complete glossary of technical terms and an alphabetically arranged table of troubles and symptoms form a most valuable and unique feature of the book. 5¼ x 7½. Cloth. 275 pages, 152 illustrations. **Price, $2.00**

Gas Engine Construction.

Or How to Build a Half-Horse-power Gas Engine. By Parsell and Weed. A practical treatise describing the theory and principles of the action of gas engines of various types, and the design and construction of a half-horse-power gas engine, with illustrations of the work in actual progress, together with dimensioned working drawings giving clearly the sizes of the various details. 300 pages. Third edition. Cloth. **Price, $3.00**

Chemistry of Gas Manufacture.

By H. M. Royles. This book covers points likely to arise in the ordinary course of the duties of the engineer or manager of a gas works not large enough to necessitate the employment of a separate chemical staff. It treats of the testing of the raw materials employed in the manufacture of illuminating coal gas and of the gas produced. The preparation of standard solutions is given as well as the chemical and physical examination of gas coal. 5¾ x 8¾. Cloth. 328 pages, 82 illustrations, 1 colored plate. **Price, $5.00**

Modern Gas Engines and Producer Gas Plants.

By R. E. Mathot, M.E. A practical treatise of 320 pages, fully illustrated by 175 detailed illustrations, setting forth the principles of gas engines and producer design, the selection and installation of an engine, conditions of perfect operation, producer-gas engines and their possibilities, the care of gas engines and producer-gas plants, with a chapter on volatile hydrocarbon and oil engines. This book has been endorsed by Dugal Clerk as a most useful work for all interested in gas engine installation and producer gas. **$3.00**

The Gasoline Engine on the Farm: Its Operation, Repair and Uses.

By Xeno W. Putnam. A useful and practical treatise on the modern gasoline and kerosene engine, its construction, management, repair and the many uses to which it can be applied in present-day farm life. It considers all the various household, shop and field uses of this up-to-date motor and includes chapters on engine installation, power transmission and the best arrangement of the power plant in reference to the work. 5¼ x 7½. Cloth. 527 pages, 179 illustrations. **Price, $3.00**

How to Run and Install Two- and Four-Cycle Marine, Gasoline Engines.

By C. Von Culin. New revised and enlarged edition just issued. The object of this little book is to furnish a pocket instructor for the beginner, the busy man who uses an engine for pleasure or profit, but who does not have the time or inclination for a technical book, but simply to thoroughly understand how to properly operate, install and care for his own engine. The index refers to each trouble, remedy and subject alphabetically. Being a quick reference to find the cause, remedy and prevention for troubles, and to become an expert with his own engine. Pocket size. Paper binding. **Price, 25 cents**

Modern Gas Tractor, Its Construction, Utility, Operation and Repair.

By Victor W. Pagé. Treats exhaustively on the design and construction of farm tractors and tractor power-plants, and gives complete instructions on their care, operation and repair. All types and sizes of gasoline, kerosene and oil tractory are described, and every phase of traction engineering practice fully covered. Invaluable to all desiring reliable information on gas motor propelled traction engines and their use. Second edition revised by much additional matter. 5¼ x 7½. Cloth, 504 pages, 228 illustrations. 3 folding plates. **Price, $3.00**

GEARING AND CAMS

Bevel Gear Tables.

By D. Ag. Engstrom. No one who has to do with bevel gears in any way should be without this book. The designer and draftsman will find it a great convenience, while to the machinist who turns up the blanks or cuts the teeth it is invaluable, as all needed dimensions are given and no fancy figuring need be done. Third edition. Cloth. **$1.50**

Change Gear Devices.

By Oscar E. Perrigo. A book for every designer, draftsman and mechanic who is interested in feed changes for any kind of machines. This shows what has been done and how. Gives plans, patents and all information that you need. Saves hunting through patent records and reinventing old ideas. A standard work of reference. Third edition. **$1.50**

Drafting of Cams.

By Louis Rouillion. The laying out of cams is a serious problem unless you know how to go at it right. This puts you on the right road for practically any kind of cam you are likely to run up against. Third edition. **35 cents**

HYDRAULICS

Hydraulic Engineering.

By Gardner D. Hiscox. A treatise on the properties, power, and resources of water for all purposes. Including the measurements of streams; the flow of water in pipes or conduits; the horse-power of falling water; turbine and impact water-wheels; wave-motors, centrifugal, reciprocating and air-lift pumps. With 300 figures and diagrams and 36 practical tables. 320 pages. **Price, $4.50**

ICE AND REFRIGERATION

Pocketbook of Refrigeration and Ice Making.

By A. J. Wallis-Taylor. This is one of the latest and most comprehensive reference books published on the subject of refrigeration and cold storage. It explains the properties and refrigerating effect of the different fluids in use, the management of refrigerating machinery and the contsruction and insulation of cold rooms with their required pipe surface for different degrees of cold; freezing mixtures and non-freezing brines, temperatures of cold rooms for all kinds of provisions, cold storage charges for all classes of goods, ice making and storage of ice, data and memoranda for constant reference by refrigerating engineers, with nearly one hundred tables containing valuable references to every fact and condition required in the installment and operation of a refrigerating plant. New edition just published. **Price, $2.00**

INVENTIONS—PATENTS

Inventor's Manual, How to Make a Patent Pay.

This is a book designed as a guide to inventors in perfecting their inventions, taking out their patents, and disposing of them. It is not in any sense a Patent Solicitor's circular nor a Patent Broker's advertisement. No advertisements of any description appear in the work. It is a book containing a quarter of a century's experience of a successful inventor, together with notes based upon the experience of many other inventors. Revised and enlarged second edition. Nearly 150 pages. Illustrated. **Price $1.25**

KNOTS

Knots, Splices and Rope Work.

By A. Hyatt Verrill. This is a practical book giving complete and simple directions for making all the most useful and ornamental knots in common use, with chapters on Splicing, Pointing, Seizing, Serving, etc. This book is fully illustrated with 154 original engravings, which show how each knot, tie or splice is formed, and its appearance when finished. The book will be found of the greatest value to campers, yachtsmen, travelers or Boy Scouts, in fact, to anyone having occasion to use or handle rope or knots for any purpose. The book is thoroughly reliable and practical, and is not only a guide but a teacher. It is the standard work on the subject. Second edition revised. 128 pages, 154 original engravings. **Price, $1.00**

LATHE WORK

Complete Practical Machinist.

By Joshua Rose. The new, twentieth revised and enlarged edition is now ready. This is one of the best-known books on machine-shop work, and written for the practical workman in the language of the workshop. It gives full, practical intsructions on the use of all kinds of metal-working tools, both hand and machine, and tells how the work should be properly done. It covers lathe work, vise work, drills and drilling, taps and dies, hardening and tempering, the making and use of tools, tool grinding, marking out work, machine tools, etc. No machinist's library is complete without this volume. 547 pages, 432 illustrations. (1920.) **Price $3.00**

The Lathe—Its Design, Construction and Operation, With Practical Examples of Lathe Work.

By Oscar E. Perrigo. A new revised edition, and the only complete American work on the subject, written by a man who knows not only how work ought to be done, but who also knows how to do it, and how to convey this knowledge to others. It is strictly up-to-date in its descriptions and illustrations. Lathe history and the relations of the lathe to manufacturing are given; also a description of the various devices for feeds and thread cutting mechanisms from early efforts in this direction to the present time. Lathe design is thoroughly discussed, including back gearing, driving cones, thread-cutting gears, and all the essential element of the modern lathe. The classification of lathes is taken up, giving the essential differences of the several types of lathes including, as is usually understood, engine lathes, bench lathes, speed lathes, forge lathes, gap lathes, pulley lathes, forming lathes, multiple-spindle lathes, rapid-reduction lathes, precision lathes, turret lathes, special lathes, electrically-driven lathes, etc. In addition to the complete exposition on construction and design, much practical matter on lathe installation, care and operation has been incorporated in the enlarged new edition. All kinds of lathe attachments for drilling, milling, etc., are described and complete instructions are given to enable the novice machinist to grasp the art of lathe operation as well as the principles involved in design. A number of difficult machining operations are described at length and illustrated. The new edition has nearly 500 pages and 350 illustrations. **Price, $3.00**

Turning and Boring Tapers.

By Fred H. Colvin. There are two ways to turn tapers; the right way and one other. This treatise has to do with the right way; it tells you how to start the work properly, how to set the lathe, what tools to use and how to use them, and forty and one other little things that you should follow. Fourth edition. **Price, 35 cents**

LIQUID AIR

Liquid Air and the Liquefaction of Gases.

By T. O'Conor Sloane. The third revised edition of this book has just been issued. Much new material is added to it; and the all important uses of liquid air and gas processes in modern industry, in the production especially of nitrogen compounds, are described. The book gives the history of the theory, discovery, and manufacture of Liquid Air, and contains an illustrated description of all the experiments that have excited the wonder of audiences all over the country. It shows how liquid air, like water, is carried hundreds of miles and is handled in open buckets. It tells what may be expected from it in the near future. A book that renders simple one of the most perplexng chemical problems of the century. Startling developments illustrated by actual experiments. It is not only a work of scientific interest and authority, but is intended for the general reader, being written in a popular style—easily understood by everyone. 400 pages fully illustrated. (1920.) **Price, $3.00**

Air-Brake Catechism.

By Robert H. Blackall. This book is a standard text book. It is the only practical and complete work published. Treats on the equipment manufactured by the Westinghouse Air Brake Company, including the E-T Locomotive Brake Equipment, the K (Quick-Service) Triple Valve for freight service; the L High Speed Triple Valve; the P-C Passenger Brake Equipment, and the Cross Compound Pump. The operation of all parts of the apparatus is explained in detail and a practical way of locating their peculiarities and remedying their defects is given. Endorsed and used by air-brake instructors and examiners on nearly every railroad in the United States. Twenty-sixth edition. 411 pages, fully illustrated with folding plates and diagrams. New edition. **Price, $2.50**

Application of Highly Superheated Steam to Locomotives.

By Robert Garbe. A practical book which cannot be recommended too highly to those motive-power men who are anxious to maintain the highest efficiency in their locomotives. Contains special chapters on Generation of Highly Superheated Steam; Superheated Steam and the Two-Cylinder Simple Engine; Compounding and Superheating; Designs of Locomotive Superheaters; Constructive Details of Locomotives Using Highly Superheated Steam. Experimental and Working Results. Illustrated with folding plates and tables. Cloth. **Price, $3.00**

Combustion of Coal and the Prevention of Smoke.

By Wm. M. Barr. To be a success a fireman must be "Light on Coal." He must keep his fire in good condition, and prevent, as far as possible, the smoke nuisance. To do this, he should know how coal burns, how smoke is formed and the proper burning of fuel to obtain the best results. He can learn this, and more too, from Barr's "Combustion of Coal." It is an absolute authority on all questions relating to the firing of a locomotive. Fifth edition. Nearly 350 pages, fully illustrated. **Price, $1.50**

Diary of a Round-House Foreman.

By T. S. Reilly. This is the greatest book of railroad experiences ever published. Containing a fund of information and suggestions along the line of handling men, organizing, etc., that one cannot afford to miss. 176 pages. **Price, $1.25**

Link Motions, Valves and Valve Setting.

By Fred H. Colvin, Associate Editor of "American Machinist." A handy book that clears up the mysteries of valve setting. Shows the different valve gears in use, how they work, and why. Piston and slide valves of different types are illustrated and explained. A book that every railroad man in the motive-power department ought to have. Fully illustrated. New revised and enlarged edition just published. **Price, 75 cents**

Train Rule Examinations Made Easy.

By G. E. Collingwood. This is the only practical work on train rules in print. Every detail is covered, and puzzling points are explained in simple, comprehensive language, making it a practical treatise for the train dispatcher, engineman, trainman and all others who have to do with the movements of trains. Contains complete and reliable information of the Standard Code of Train Rules for single track. Shows signals in colors, as used on the different roads. Explains fully the practical application of train orders, giving a clear and definite understanding of all orders which may be used. Second edition revised. 256 pages. Fully illustrated with train signals in colors. **Price, $1.50**

Locomotive Boiler Construction.

By Frank A. Kleinhans. The only book showing how locomotive boilers are built in modern shops. Shows all types of boilers used; gives details of construction; practical facts, such as life of riveting punches and dies, work done per day, allowance for bending and flanging sheets and other data that means dollars to any railroad man. Second edition. 451 pages, 334 illustrations. Six folding plates. Cloth. **Price, $3.50**

Locomotive Breakdowns and Their Remedies.

By Geo. L. Fowler. Revised by Wm. W. Wood, Air-Brake Instructor. Pocket edition. It is out of the question to try and tell you about every subject that is covered in this pocket edition of Locomotive Breakdowns. Just imagine all the common troubles that an engineer may expect to happen some time, and then add all of the unexpected ones, troubles that could occur, but that you had never thought about, and you will find that they are all treated with the very best methods of repair. Walschaert Locomotive Valve Gear Troubles, Electric Headlight Troubles, as well as Questions and Answers on the Air Brake, are all included. Eighth edition. 294 pages. Fully illustrated. **Price, $1.50**

Locomotive Catechism.

By Robert Grimshaw. Twenty-eighth revised and enlarged edition. This may well be called an encyclopedia of the locomotive. Contains over 4,000 examination questions with their answers, including among them those asked at the first, second and third year's examinations. 825 pages, 437 illustrations and 3 folding plates. **Price, $2.50**

Westinghouse E. T. Air-Brake Instruction Pocketbook Catechism.

By Wm. W. Wood, Air-Brake Instructor. A practical work containing examination questions and answers on the E. T. Equipment. Covering what the E. T. Brake is. How it should be operated. What to do when defective. Not a question can be asked of the engineman up for promotion on either the No. 5 or the No. 6 E. T. equipment that is not asked and answered in the book. If you want to thoroughly understand the E. T. equipment get a copy of this book. It covers every detail. Makes air-brake troubles and examinations easy. Fully illustrated with colored plates, showing various pressures. Cloth. (1920.) **Price, $2.50**

Practical Instructor and Reference Book for Locomotive Firemen and Engineers.

By Chas. F. Lockhart. An entirely new book on the locomotive. It appeals to every railroad man, as it tells him how things are done and the right way to do them. Written by a man who has had years of practical experience in locomotive shops and on the road firing and running. The information given in this book cannot be found in any other similar treatise. Eight hundred and fifty-one questions with their answers are included, which will prove specially helpful to those preparing for examination. 368 pages, 88 illustrations. Cloth. **Price, $2.00**

Prevention of Railroad Accidents, or Safety in Railroading.

By George Bradshaw. This book is a heart-to-heart talk with railroad employees, dealing with facts, not theories, and showing the men in the ranks, from every-day experience, how accidents occur and how they may be avoided. The book is illustrated with seventy original photographs and drawings showing the safe and unsafe methods of work. No visionary schemes, no ideal pictures. Just plain facts and practical suggestions are given. Every railroad employee who reads the book is a better and safer man to have in railroad service. It gives just the information which will be the means of preventing many injuries and deaths. All railroad employees should procure a copy; read it, and do their part in preventing accidents. 169 pages. Pocket size. Fully illustrated. **Price, 50 cents**

Walschaert Locomotive Valve Gear.

By Wm. W. Wood. If you would thoroughly understand the Walschaert Valve Gear, you should possess a copy of this book. The author divides the subject into four divisions, as follows: I. Analysis of the gear. II. Designing and erection of the gear. III. Advantages of the gear. IV. Questions and answers relating to the Walschaert Valve Gear. This book is specially valuable to those preparing for promotion. Third edition. 245 pages. Fully illustrated. Cloth. **Price, $2.50**

MACHINE SHOP PRACTICE

Modern Machine Shop Construction, Equipment and Management.

By Oscar E. Perrigo. The only work published that describes the Modern Machine Shop or Manufacturing Plant from the time the grass is growing on the site intended for it until the finished product is shipped. Just the book needed by those contemplating the erection of modern shop buildings, the rebuilding and reorganization of old ones or the introduction of Modern Shop Methods, Time and Cost Systems. It is a book written and illustrated by a practical shop man for practical shop men who are too busy to read theories and want facts. It is the most complete all-around book of its kind ever published. Second edition. 384 pages, 219 original and specially-made illustrations. **Price, $5.00**

EVERY PRACTICAL MAN NEEDS
A MAGAZINE WHICH WILL TELL HIM
HOW TO MAKE AND DO THINGS

HAVE US ENTER YOUR SUBSCRIPTION

to the best mechanical magazine on the market. Only **Two Dollars** a year for twelve numbers. Subscribe to-day to

EVERYDAY ENGINEERING

A monthly magazine devoted to practical mechanics for everyday men. Its aim is to popularize engineering as a science, teaching the elements of applied mechanics and electricity in a straightforward and understandable manner. The magazine maintains its own experimental laboratory, where the devices described in articles submitted to the Editor are first tried out and tested before they are published. This important innovation places the standard of the published material very high, and it insures accuracy and dependability.

The magazine is the only one in this country that specializes in practical model building. Articles in past issues have given comprehensive designs for many model boats, including submarines and chasers, model steam and gasoline engines, electric motors and generators, etc., etc. This feature is a permanent one in the magazine.

Another popular department is that devoted to automobiles and airplanes. Care, maintenance, and operation receive full and authoritative treatment. Every article is written from the practical, everyday man standpoint, rather than from that of the professional.

The magazine entertains while it instructs. It is a journal of practical, dependable information, given in a style that it may be readily assimilated and applied by the man with little or no technical training. The aim is to place before the man who leans toward practical mechanics a series of concise, crisp, readable talks on what is going on and *how it is done.* These articles are profusely illustrated with clear, snappy photographs, specially posed to illustrate the subject in the magazine's own studio by its own staff of technically-trained illustrators and editors.

The subscription price of the magazine is two dollars per year in U. S., two dollars and twenty-five cents in Canada and three dollars in foreign countries. Sample copy sent on receipt of twenty cents.

Machine Shop Arithmetic.

By Colvin-Cheney. Most popular book for shop men. Shows how all shop problems are worked out and "why." Includes change gears for cutting any threads; drills, taps, shink and force fits; metric system of measurements and threads. Used by all classes of mechanics and for instruction in Y. M. C. A. and other schools. Seventh edition. 131 pages. **Price, 75 cents.**

Abrasives and Abrasive Wheels.

By Fred B. Jacobs. A new book for everyone interested in abrasives or grinding. A careful reading of the book will not only make mechanics better able to use abrasives inteligently, but it will also tell the shop superintendent of many short cuts and efficiency-increasing kinks. The economic advantage in using large grinding wheels are fully explained, together with many other things that will tend to give the superintendent or workman a keen insight into abrasive engineering. 340 pages, 200 illustrations. This is an indispensable book for every machinist. **Price, $3.00**

American Tool Making and Interchangeable Manufacturing.

By J. V. Woodworth. In its 500-odd pages the one subject only, Tool Making, and whatever relates thereto, is dealt with. The work stands without a rival. It is a complete practical treatise on the art of American Tool Making and system of interchangeable manufacturing as carried on to-day in the United States. In it are described and illustrated all of the different types and classes of small tools, fixtures, devices and special appliances which are in general use in all machine-manufacturing and metal-working establishments where economy, capacity and interchangeability in the production of machined metal parts are imperative. The science of jig making is exhaustively discussed, and particular attention is paid to drill jigs, boring, profiling and milling fixtures and other devices in which the parts to be machined are located and fastened within the contrivances. All of the tools, fixtures and devices illustrated and described have been or are used for the actual production of work, such as parts of drill presses, lathes, patented machinery, typewriters, electrical apparatus, mechanical appliances, brass goods, composition parts, mould products, sheet metal articles, drop forgings, jewelry, watches, medals, coins, etc. Second edition. 531 pages. **Price, $4.50**

Henley's Encyclopedia of Practical Engineering and Allied Trades.

Edited by Joseph G. Horner, A.M.I.Mech.E. This book covers the entire practice of Civil and Mechanical Engineering. The best known experts in all branches of engineering have contributed to these volumes. The Cyclopedia is admirably well adapted to the needs of the beginner and the self-taught practical man, as well as the mechanical engineer, designer, draftsman, shop superintendent, foreman and machinist.

It is a modern treatise in five volumes. Handsomely bound in half morocco, each volume containing nearly 500 pages, with thousands of illustrations, including diagrammatic and sectional drawings with full explanatory details.

Price, $30.00. For the complete set of five volumes.

THE WHOLE FIELD OF MECHANICAL MOVEMENTS COVERED BY MR. HISCOX'S TWO BOOKS

We publish two books by Gardner D. Hiscox that will keep you from "inventing" things that have been done before, and suggest ways of doing things that you have not thought of before. Many a man spends time and money, pondering over some mechanical problem, only to learn, after he has solved the problem, that the same thing has been accomplished and put in practice by others long before. Time and money spent in an effort to accomplish what has already been accomplished are time and money lost. The whole field of mechanics, every known mechanical movement, and practically every device is covered by these two books. If the thing you want has been invented, it is illustrated in them. If it hasn't been invented, then you'll find in them the nearest things to what you want, some movement or device that will apply in your case, perhaps; or which will give you a key from which to work. No book or set of books ever published is of more real value to the inventor, draftsman or practical mechanic than the two volumes described below.

Mechanical Movements, Powers and Devices.

By GARDNER D. HISCOX. This is a collection of 1,890 engravings of different mechanical motions and appliances, accompanied by appropriate text, making it a book of great value to the inventor, the draftsman, and to all readers with mechanical tastes. The book is divided into eighteen sections or chapters, in which the subject-matter is classified under the following heads: Mechanical Powers; Transmission of Power; Measurement of Power; Steam Power; Air Power Appliances; Electric Power and Construction; Navigation and Roads; Gearing; Motion and Devices; Controlling Motion; Horological; Mining; Mill and Factory Appliances; Construction and Devices; Drafting Devices; Miscellaneous Devices, etc. Fifteenth edition. 400 octavo pages.
Price, $4.00

Mechanical Appliances, Mechanical Movements and Novelties of Construction.

By GARDNER D. HISCOX. This is a supplementary volume to the one upon mechanical movements. Unlike the first volume, which is more elementary in character, this volume contains illustrations and descriptions of many combinations of motions and of mechanical devices and appliances found in different lines of machinery, each device being shown by a line drawing with a description showing its working parts and the method of operation. From the multitude of devices described and illustrated might be mentioned, in passing, such items as conveyors and elevators, Prony brakes, thermometers, various types of boilers, solar engines, oil-fuel burners, condensers, evaporators, Corliss and other valve gears, governors, gas engines, water motors of various descriptions, air ships, motors and dynamos, automobiles and motor bicycles, railway lock signals, car couplers, link and gear motions, ball bearings, breech block mechanism for heavy guns, and a large accumulation of others of equal importance. 1,000 specially made engravings. 396 octavo pages. Fourth revised edition. **Price, $4.00**

"Shop Kinks."

By Robert Grimshaw. This shows special methods of doing work of various kinds, and releasing cost of production. Has hints and kinks from some of the largest shops in this country and Europe. You are almost sure to find some that apply to your work, and in such a way as to save time and trouble. 400 pages. Fifth edition. Cloth. **Price, $3.00**

Machine Shop Tools and Shop Practice.

By W. H. Vandervoort. A work of 555 pages and 673 illustrations, describing in every detail the construction, operation. and manipulation of both hand and machine tools. Includes chapters on filing, fitting, and scraping surfaces; on drills, reamers, taps, and dies; the lathe and its tools; planers, shapers, and their tools; milling machines and cutters; gear cutters and gear cutting; drilling machines and drill work; grinding machines and their work; hardening and tempering; gearing, belting, and transmission machinery; useful data and tables. Sixth, edition. Cloth. **Price, $4.50**

Model Making.

By Raymond Francis Yates. A new book for the mechanic and model maker. This is the first book of its kind to be published in this country and all those interested in model engineering should have a copy. The first eight chapters are devoted to such subjects as Silver Soldering, Heat Treatment of Steel, Lathe Work, Pattern Making, Grinding, etc. The remaining twenty-four chapters describe the construction of various models such as rapid fire naval guns, speed boats, model steam engines, turbines, etc.

This book must not be confused with those describing the construction of toys now on the market. It is a practical treatise on model engineering and construction. 400 pages. 301 illustrations. **Price, $3.00**

The Modern Machinist.

By John T. Usher. This book might be called a compendium of shop methods, showing a variety of special tools and appliances which will give new ideas to many mechanics from the superintendent down to the man at the bench. It will be found a valuable addition to any machinist's library and should be consulted whenever a new or difficult job is to be done, whether it is boring, milling, turning, or planing, as they are all treated in a practical manner. Fifth edition. 320 pages, 250 illustrations. Cloth. **Price, $2.50**

Threads and Thread Cutting.

By Colvin and Stabel. This clears up many of the mysteries of thread cutting, such as double and triple threads, internal threads, catching threads, use of hobs, etc. Contains a lot of useful hints and several tables. Third edition. **35 cents**

MARINE ENGINEERING

The Naval Architect's and Shipbuilder's Pocket-book

of Formulæ, Rules, and Tables and Marine Engineer's and Surveyor's Handy Book of Reference. By CLEMENT MACKROW and LLOYD WOOLLARD. The eleventh revised and enlarged edition of this most comprehensive work has just been issued. It is absolutely indispensable to all engaged in the Shipbuilding Industry, as it condenses into a compact form all data and formulæ that are ordinarily required. The book is completely up to date, including among other subjects a section on Aeronautics. 750 pages, limp leather binding.

Price, $6.00 net

Marine Engines and Boilers, Their Design and Construction. The Standard Book.

By DR. G. BAUER, LESLIE S. ROBERTSON and S. BRYAN DONKIN. In the words of Dr. Bauer, the present work owes its origin to an oft felt want of a condensed treatise embodying the theoretical and practical rules used in designing marine engines and boilers. The need of such a work has been felt by most engineers engaged in the construction and working of marine engines, not only by the younger men, but also by those of greater experience. The fact that the original German work was written by the chief engineer of the famous Vulcan Works, Stettin, is in itself a guarantee that this book is in all respects thoroughly up-to-date, and that it embodies all the information which is necessary for the design and construction of the highest types of marine engines and boilers. It may be said that the motive power which Dr. Bauer has placed in the fast German liners that have been turned out of late years from the Stettin Works represent the very best practice in marine engineering of the present day. The work is clearly written, thoroughly systematic, theoretically sound; while the character of the plans, drawings, tables, and statistics is without reproach. The illustrations are careful reproductions from actual working drawings, with some well-executed photographic views of completed engines and boilers. 744 pages, 550 illustrations, and numerous tables. Cloth. **Price, $10.00 net**

MANUAL TRAINING

Economics of Manual Training.

By LOUIS ROUILLION. The only book that gives just the information needed by all interested in manual training, regarding buildings, equipment and supplies. Shows exactly what is needed for all grades of the work from the Kindergarten to the High and Normal School. Gives itemized lists of everything needed and tells just what it ought to cost. Also shows where to buy supplies. Illustrated. Second edition. Cloth. **Price, $2.00**

MINING

Prospector's Field-Book and Guide.

By H. S. Osborn. 1920 edition, revised and enlarged by M. W. von Bernewitz. The last edition of this volume was published in 1910. It and the previous seven editions were suitable for those times. The new ninth (1920) edition will be found suitable for the present time. While the old-time prospector will always be an important factor, the knowledge of and search for the common and rarer minerals is bringing out men who are trained to some degree. In the field they need a handy and suggestive pocket-book containing hints on prospecting—where to search and how to test—couched in simple terms. The chapter on preliminary instructions covers the fundamentals of a study of the earth's crust. Then follow discussions on practical mineralogy, crystallography, the value of the blowpipe in prospecting, surveying, and chemical tests in the field. Separate chapters are given to the precious and base metals, also to the non-metallic minerals. The chapter on the non-ferrous or alloy group of minerals is entirely new, while the section on oil has been expanded. Surficial indications for copper receive full attention. The chapter on gems has been rewritten and matters concerning gemstones used for industrial purposes, such as abrasives, included. A general chapter covers many useful minerals and salts. An important guide and suggestive aid throughout the new book are the many brief descriptions of ore deposits of all minerals occurring in scattered parts of the world. No other prospector's book contains this class of information. In the appendix will be found numbers of useful tables, and a complete glossary of mining and mineralogical terms. The ninth edition of Osborn's "Prospector's Field Book and Guide" will be found up to date, worth while, and full value for the money asked. Flexible fabrikoid. 375 pages. 57 illustrations. 1920 edition. **Price, $3.00**

PATTERN MAKING

Practical Pattern Making.

By F. W. Barrows. This book, now in its second edition, is a comprehensive and entirely practical treatise on the subject of pattern making, illustrating pattern work in both wood and metal, and with definite instructions on the use of plaster of paris in the trade. It gives specific and detailed descriptions of the materials used by pattern makers and describes the tools; both those for the bench and the more interesting machine tools; having complete chapters on the lathe, the circular saw and the band saw. It gives many examples of pattern work, each one fully illustrated and explained with much detail. These examples, in their great variety, offer much that will be found of interest to all pattern makers, and especially to the younger ones, who are seeking information on the more advanced branches of their trade. Containing nearly 350 pages and 170 illustrations. Second edition, revised and enlarged. **Price, $2.50**

PERFUMERY

Henley's Twentieth Century Book of Receipts, Formulas and Processes.

Edited by G. D. Hiscox. The most valuable techno-chemical receipt book published. Contains over 10,000 practical receipts, many of which will prove of special value to the perfumer. **Price, $4.00**

Perfumes and Cosmetics, Their Preparation and Manufacture.

By G. W. Askinson, Perfumer. A comprehensive treatise, in which there has been nothing omitted that could be of value to the perfumer or manufacturer of toilet preparations. Complete directions for making handkerchief perfumes, smelling-salts, sachets, fumigating pastiles; preparations for the care of the skin, the mouth, the hair, cosmetics, hair dyes and other toilet articles are given, also a detailed description of aromatic substances; their nature, tests of purity, and wholesale manufacture, including a chapter on synthetic products, with formulas for their use. A book of general, as well as professional interest, meeting the wants not only of the druggist and perfume manufacturer, but also of the general public. Fourth edition much enlarged and brought up-to-date. Nearly 400 pages, illustrated, **$5.00**

PLUMBING

Standard Practical Plumbing.

By R. M. Starbuck. This is a complete treatise and covers the subject of modern plumbing in all its branches. It treats exhaustively on the skilled work of the plumber and the theory underlying plumbing devices and operations, and commends itself at once to anyone working in any branch of the plumbing trade. A large amount of space is devoted to a very complete and practical treatment of the subjects of hot water supply, circulation and range boiler work. Another valuable feature is the special chapter on drawing for plumbers. The illustrations, of which there are three hundred and forty-seven, one hundred being full-page plates, were drawn expressly for this book and show the most modern and best American practice in plumbing construction. 6½ x 9¼. Cloth, 406 pages, 347 illustrations. **Price, $3.50**

Mechanical Drawing for Plumbers.

By R. M. Starbuck. A concise, comprehensive and practical treatise on the subject of mechanical drawing in its various modern applications to the work of all who are in any way connected with the plumbing trade. Nothing will so help the plumber in estimating and in explaining work to customers and workmen as a knowledge of drawing, and to the workman it is of inestimable value if he is to rise above his position to positions of greater responsibility. 150 illustrations. **Price, $2.00**

Modern Plumbing Illustrated.

By R. M. STARBUCK. The author of this book, Mr. R. M. Starbuck, is one of the leading authorities on plumbing in the United States. The book represents the highest standard of plumbing work. A very comprehensive work, illustrating and describing the drainage and ventilation of dwellings, apartments and public buildings. The very latest and most approved methods in all branches of sanitary installation are given. The standard book for master plumbers, architects, builders, plumbing inspectors, boards of health, boards of plumbing examiners and for the property owner, as well as the workman and apprentice. It contains fifty-seven entirely new and large full pages of illustrations with descriptive text, all of which have been made specially for this work. These plates show all kinds of modern plumbing work. Each plate is accompanied by several pages of text, giving notes and practical suggestions, sizes of pipe, proper measurements for setting up work, etc. Suggestions on estimating plumbing construction are also included. 407 octavo pages, fully illustrated by 57 full-page engravings. **Price, $5.00**

RECIPE BOOK

Henley's Twentieth Century Book of Recipes, Formulas and Processes.

Edited by GARDNER D. HISCOX. The most valuable techno-chemical formulæ book published, including over 10,000 selected scientific, chemical, technological and practical recipes and processes. This book of 800 pages is the most complete book of recipes ever published, giving thousands of recipes for the manufacture of valuable articles for everyday use. Hints, helps, practical ideas and secret processes are revealed within its pages. It covers every branch of the useful arts and tells thousands of ways of making money and is just the book everyone should have at his command. The pages are filled with matters of intense interest and immeasurable practical value to the photographer, the perfumer, the painter, the manufacturer of glues, pastes, cements and mucilages, the physician, the druggist, the electrician, the dentist, the engineer, the foundryman, the machinist, the potter, the tanner, the confectioner, the chiropodist, the manufacturer of chemical novelties and toilet preparations, the dyer, the electroplater, the enameler, the engraver, the provisioner, the glass worker, the goldbeater, the watchmaker and jeweler, the ink manufacturer, the optician, the farmer, the dairyman, the paper maker, the metal worker, the soap maker, the veterinary surgeon, and the technologist in general. A book to which you may turn with confidence that you will find what you are looking for. A mine of information up-to-date in every respect. Contains an immense number of formulas that every one ought to have that are not found in any other work. 1920 edition. Cloth binding. **Price, $4.00**

RUBBER

Henley's Twentieth Century Book of Receipts, Formulas and Processes.

Edited by Gardner D. Hiscox. Contains upward of 10,000 practical receipts, including among them formulas on artificial rubber.

Price, $4.00

Rubber Hand Stamps and the Manipulation of India Rubber.

By T. O'Conor Sloane. This book gives full details of all points, treating in a concise and simple manner the elements of nearly everything it is necessary to understand for a commencement in any branch of the India rubber manufacture. The making of all kinds of rubber hand stamps, small articles of India rubber, U. S. Government composition, dating hand stamps, the manipulation of sheet rubber, toy balloons, India rubber solutions, cements, blackings, renovating varnish, and treatment for India rubber shoes, etc.; the hektograph stamp inks, and miscellaneous notes, with a short account of the discovery, collection and manufacture of India rubber are set forth in a manner designed to be readily understood, the explanation being plain and simple. Third edition. 175 pages, illustrated. **Price, $1.25**

SAWS

Saw Filing and Management of Saws.

By Robert Grimshaw. A practical hand book on filing, gumming, swaging, hammering and the brazing of band saws, the speed, work, and power to run circular saws, etc. A handy book for those who have charge of saws, or for those mechanics who do their own filing, as it deals with the proper shape and pitches of saw teeth of all kinds and gives many useful hints and rules for gumming, setting, and filing, and is a practical aid to those who use saws for any purpose. Third edition, revised and enlarged. Illustrated. **Price, $1.50**

SCREW CUTTING

Threads and Thread Cutting.

By Colvin and Stable. This clears up many of the mysteries of thread cutting, such as double and triple threads, internal threads, catching threads, use of hobs, etc. Contains a lot of useful hints and several tables. Third edition. **35 cents**

STEAM ENGINEERING

Horse-power Chart.

Shows the horse-power of any stationary engine without calculation. No matter what the cylinder diameter or stroke; the steam pressure or cut-off; the revolutions, or whether condensing or non-condensing, it's all there. Easy to use, accurate, and saves time and calculations. Especially useful to engineers and designers. **Price, 50 cents**

Steam Engine Troubles.

By H. Hamkens. It is safe to say that no book has ever been published which gives the practical engineer such valuable and comprehensive information on steam engine design and troubles. There are descriptions of cylinders, valves, pistons, frames, pillow blocks and other bearings, connecting rods, wristplates, dashpots, reachrods, valve gears, governors, piping, throttle and emergency valves, safety stops, flywheels, oilers, etc. If there is any trouble with these parts, the book gives you the reasons and tells how to remedy them. 350 pages, 276 illustrations. **Price, $2.50**

American Stationary Engineering.

By W. E. Crane. A new book by a well-known author. Begins at the boiler room and takes in the whole power plant. Contains the result of years of practical experience in all sorts of engine rooms and gives exact information that cannot be found elsewhere. It's plain enough for practical men and yet of value to those high in the profession. Has a complete examination for a license. Third edition revised and enlarged. 345 pages. 131 illustrations. Cloth. **Price, $2.50**

Steam Engine Catechism.

By Robert Grimshaw. This volume of 413 pages is not only a catechism on the question and answer principle, but it contains formulas and worked-out answers for all the steam problems that appertain to the operation and management of the steam engine. Sixteenth edition. **Price, $2.00**

Boiler Room Chart.

By Geo. L. Fowler. A chart—size 14 x 28 inches—showing in isometric perspective the mechanism belonging in a modern boiler room. The various parts are shown broken or removed, so that the internal construction is fully illustrated. Each part is given a reference number, and these, with the corresponding name, are given in a glossary printed at the sides. **Price, 25 cents**

Engine Runner's Catechism.

By Robert Grimshaw. Tells how to erect, adjust and run the principal steam engines in use in the United States. The work is of a handy size for the pocket. To young engineers this catechism will be of great value, especially to those who may be preparing to go forward to be examined for certificates of competency; and to engineers generally it will be of no little service, as they will find in this volume more really practical and useful information than is to be found anywhere else within a like compass. 387 pages. Seventh edition. **Price, $2.00**

Modern Steam Engineering in Theory and Practice.

By Gardner D. Hiscox. This is a complete and practical work issued for stationary engineers and firemen dealing with the care and management of boilers, engines, pumps, superheated steam, refrigerating machinery, dynamos, motors, elevators, air compressors, and all other branches with which the modern engineer must be familiar. Nearly 200 questions with their answers on steam and electrical engineering, likely to be asked by the examining board, are included. Third edition. 487 pages, 405 engravings. Cloth. **Price, $3.50**

Steam Engineer's Arithmetic.

By Colvin-Cheney. A practical pocket book for the steam engineer. Shows how to work the problems of the engine room and shows "why." Tells how to figure horse-power of engines and boilers; area of boilers; has tables of areas and circumferences; steam tables; has a dictionary of engineering terms. Puts you onto all of the little kinks in figuring whatever there is to figure around a power plant. Tells you about the heat unit; absolute zero; adiabatic expansion; duty of engines; factor of safety; and 1,001 other things; and everything is plain and simple—not the hardest way to figure, but the easiest. Second edition. **Price, 75 cents**

STEAM HEATING and VENTILATING

Practical Steam, Hot-Water Heating and Ventilation.

By A. G. King. This book has been prepared for the use of all engaged in the business of steam, hot-water heating and ventilation. Tells how to get heating contracts, how to install heating and ventilating apparatus, the best business methods to be used, with "Tricks of the Trade" for shop use. Rules and data for estimating radiation and cost and such tables and information as make it an indispensable work for everyone interested in steam, hot-water heating and ventilation. It describes all the principal systems of steam, hot-water, vacuum, vapor and vacuum-vapor heating, together with the new accelerated systems of hot-water circulation, including chapters on up-to-date methods of ventilation and the fan or blower system of heating and ventilation. Second edition. 367 pages, 300 detailed engravings. Cloth. **$3.50**

500 Plain Answers to Direct Questions on Steam, Hot-Water, Vapor and Vacuum Heating Practice.

By Alfred G. King. This work, just off the press, is arranged in question and answer form; it is intended as a guide and text-book for the younger inexperienced fitter and as a reference book for all fitters. All long and tedious discussions and descriptions formerly considered so important have been eliminated, and the theory and laws of heat and the various old and modern methods and appliances used for heating and ventilating are treated in a concise manner. This is the standard Question and Answer examination book on Steam and Hot Water Heating, etc. 200 pages, 127 illustrations. Octavo. Cloth. **Price, $2.00**

STEEL

Hardening, Tempering, Annealing and Forging of Steel.

By J. V. Woodworth. A book containing special directions for the successful hardening and tempering of all steel tools. Milling cutters, taps, thread dies, reamers, both solid and shell, hollow mills, punches and dies, and all kinds of sheet-metal working tools, shear blades, saws, fine cutlery and metal-cutting tools of all descriptions, as well as for all implements of steel, both large and small, the simplest, and most satisfactory hardening and tempering processes are presented. 320 pages, 250 illustrations. Fourth edition. Cloth. **Price, $3.00**

Steel: Its Selection, Annealing, Hardening and Tempering.

By E. R. Markham. This work was formerly known as "The American Steel Worker," but on the publication of the new, revised edition, the publishers deemed it advisable to change its title to a more suitable one. This is the standard work on hardening, tempering, and annealing steel of all kinds. This book tells how to select, and how to work, temper, harden, and anneal steel for everything on earth. It is the standard book on selecting, hardening, and tempering all grades of steel. 400 pages. Very fully illustrated. Fourth edition. **Price, $3.00**

TRACTORS

The Modern Gas Tractor.

By Victor W. Pagé. A complete treatise describing all types and sizes of gasoline, kerosene, and oil tractors. Considers design and construction exhaustively, gives complete instruction for care, operation and repair, outlines all practical applications on the road and in the field. The best and latest work on farm tractors and tractor power plants. A work needed by farmers, students, blacksmiths, mechanics, salesmen, implement dealers, designers, and engineers. Second edition revised and much enlarged. 504 pages. Nearly 300 illustrations and folding plates. **Price, $3.00**

TURBINES

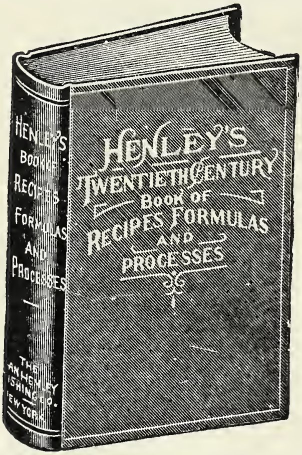
Marine Steam Turbines.

By Dr. G. Bauer and O. Lasche. Assisted by E. Ludwig and H. Vogel. Translated from the German and edited by M. G. S. Swallow. The book is essentially practical and discusses turbines in which the full expansion of steam passes through a number of separate turbines arranged for driving two or more shafts, as in the Parsons system, and turbines in which the complete expansion of steam from inlet to exhaust pressure occurs in a turbine on one shaft, as in the case of the Curtis machines. It will enable a designer to carry out all the ordinary calculation necessary for the construction of steam turbines, hence it fills a want which is hardly met by larger and more theoretical works. Numerous tables, curves and diagrams will be found, which explain with remarkable lucidity the reason why turbine blades are designed as they are, the course which steam takes through turbines of various types, the thermodynamics of steam turbine calculation, the influence of vacuum on steam consumption of steam turbines, etc. In a word, the very information which a designer and builder of steam turbines most requires. Large octavo, 214 pages. Fully illustrated and containing 18 tables, including an entropy chart. **Price, $4.00 net**

The Most Valuable Techno-Chemical Recipe Book Ever Offered to the Public!

Henley's Twentieth Century Book of RECIPES, FORMULAS AND PROCESSES

Price $4.00



THIS book of 800 pages is the most complete Book of Recipes ever published, giving thousands of recipes for the manufacture of valuable articles for every-day use. Hints, Helps, Practical Ideas and Secret Processes are revealed within its pages. It covers every branch of the useful arts and tells thousands of ways of making money and is just the book everyone should have at his command.

The pages are filled with matters of intense interest and immeasurable practical value to the Photographer, the Perfumer, the Painter, the Manufacturer of Glues, Pastes, Cements and Mucilages, the Physician, the Druggist, the Electrician, the Dentist, the Engineer, the Foundryman, the Machinist, the Potter, the Tanner, the Confectioner, the Chiropodist, the Manufacturer of Chemical Novelties and Toilet Preparations, the Dyer, the Electroplater, the Enameler, the Engraver, the Provisioner, the Glass Worker, the Goldbeater, the Watchmaker and Jeweler, the Ink Manufacturer, the Optician, the Farmer, the Dairyman, the Paper Maker, the Metal Worker, the Soap Maker, the Veterinary Surgeon and the Technologist in general.

A book to which you may turn with confidence that you will find what you are looking for. A mine of information, up-to-date in every respect. Contains an immense number of formulas that every one ought to have that are not found in any other work.

10,000 Practical Formulas and Processes
The Best Way to Make Everything

ONE USEFUL RECIPE WILL BE WORTH MORE THAN TEN TIMES THE PRICE OF THE BOOK

(See page 35 for further description of the book.)

UNIVERSITY OF ILLINOIS-URBANA
621.351C65M C001
THE MODERN ELECTROPLATER$NY
3 0112 008052117